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TO

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PROFESSOR OF MEDICAL CHEMISTRY AND TOXICOLOGY, JEFFERSON MEDICAL
COLLEGE OF PHILADELPHIA,

WHO KINDLY ENCOURAGED THE WRITER

IN THE PREPARATION OF THIS

LITTLE WORK,

AND BEFRIENDED HIM IN MANY OTHER WAYS,

This Volume

IS GRATEFULLY INSCRIBED BY

THE AUTHOR.

PREFACE TO THE FOURTH EDITION.

THE necessity of providing for another edition of this little work within less than two years since the last large edition was published cannot help but confirm the impression that it has proved itself useful and a desirable aid to the student of medicine.

The present edition was not found to need further additions, but it has been carefully revised to eliminate the few errors that were yet contained in its text.

The author wishes to express his thanks to the many teachers of this branch who have written to him approvingly of his work and have recommended it to their students, and he trusts that it may still continue to be appreciated by them.

L. W.

MAY, 1893.

PREFACE TO THE THIRD EDITION.

THE call for a third edition of this little book, after two editions of two thousand copies of each have been exhausted within three years, is certainly gratifying to the author, and assures him that his aim to present it as an aid to the medical student in his pursuit of chemistry has been realized. He thinks that this compend has not interfered with more thorough reading from text-books, but has helped to make these better understood, and has thus rendered the path of the medical student in this direction less difficult.

It was not found necessary materially to enlarge the subject in this edition. But the text has been carefully gone over. A few errors were corrected, and several tables, of the elements, weights and measures with rules for converting them, thermometric scales, etc., were appended.

Trusting that this issue will have the same generous reception from all parts of the country which has been accorded to the former editions, the author hopes that it will be a welcome friend to the student, which will help him better to appreciate the subject under consideration, and in doing so extend his usefulness as a medical practitioner.

L. W.

AUGUST, 1891.

PREFACE TO THE FIRST EDITION.

An extensive experience in preparing medical students for examination in Chemistry has satisfied the writer that the incomplete knowledge of this department of medical science, so often exhibited by students and physicians, is generally due to their inability to study the subject thoroughly without encroaching in too great a degree on the time required for the more practical branches of their profession.

Most students appear to be justified in claiming that they have derived much profit from the systematic course of "quizzing" which is in vogue at the medical schools This benefit is attributable, no doubt, to the fact that by this mode of instruction essential points are brought out in the form of questions which exact attentive consideration before adequate answers to them can be given.

In the volume here presented the author has the same object in view, and while he trusts that it will not be the means of dispensing with the deeper study of the subject, he feels assured that unless the frame-work of knowledge be first well constructed, substantial progress will be quite impossible.

If this little work shall tend to give students a better understanding of Chemistry, and with it a greater love, or perhaps less of a distaste, for the pursuit in connection with their medical studies, the writer considers that he will have achieved much of that which he attempted.

As an introductory course to Chemistry in most, if not in all, medical colleges includes the principles of Physics, some essential questions on this subject precede the chemical part of the work. Theoretical Chemistry, though treated in a separate chapter, is also frequently referred to throughout the text. The classification of the elements is somewhat at variance with the most modern ideas of pure Chemistry, but it has been given with the view of presenting the matter in logical sequence to the medical mind. Toxicology has received ample consideration under the head of each element or compound which possesses markedly poisonous properties. Analytical processes have been brought out as far as compatible with the condensation of so large a subject within so limited a space. No separate chapter or part is devoted to the "urine and its analysis," its components being considered in the order of their precedence in the adopted arrangement.

The questions and answers of this Manual have been so arranged as to conform to the principal text-books on the subject. For this purpose the authoritative works of Fownes, Attfield, Richter, Charles, Barker, and Witthaus, as well as Holland on the Urine, and Draper and Ganot on Physics, have been freely used in its preparation.

L. W.

PHILADELPHIA, PA., 333 South Twelfth St.
August, 1888.

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ESSENTIALS OF MEDICAL CHEMISTRY.

PHYSICS.

Weights, Measures, and Specific Gravity.

What is weight?

The amount of force necessary to neutralize the attraction of the earth upon a body.

State the different kinds of weight.

Apparent, absolute, and specific.

Define these three.

Apparent weight is that of a body in the air; absolute that in vacuo; specific, the relative weight of a body in comparison with that of the same volume of some other medium.

Which system of weights and measures is employed in chemistry and chemical operations?

The French or metric system based upon the metre as unit.

Give the subdivisions of a metre.

It is subdivided into 10 decimetres, 100 centimetres, 1000 millimetres.

What are the terms for decimal multiples of the metre?

10 metres equal to one dekametre.
100 metres equal to one hektometre.
1000 metres equal to one kilometre.

State the unit of fluid measure of the metric system.

The cube of one centimetre or one cubic centimetre, usually abbreviated as 1 c.c.

How much is one litre?

1000 cubic centimetres.

Give the unit of metric weight.

One gram, equal to 15.432 grains.

How is the gram derived?

From a cubic centimetre of distilled water at its maximum density (+ 4° C.).

What are the decimal subdivisions of a gram?

1 gram=10 decigrams=100 centigrams=1000 milligrams.

How are the decimal multiples of a gram designated?

By Greek numerals. 10 grams = 1 dekagram; 100 grams = 1 hektogram; 1000 grams = 1 kilogram.

Give the equivalents in Troy weight of 1 gram, 1 kilogram, also in grams of 1 grain and 1 oz. Troy.

1 gram = 15.434 grains; 1 kilogram = 2.679 lbs. Troy; 1 grain = 0.065 grams; 1 oz. Troy = 31.103 grams.

What are scales and balances?

Instruments to determine the weights of bodies.

State what chemical balances are, and their principal parts.

Instruments indicating at least one milligram, having knife edges on which the beams and hangers are equipoised.

How are chemical balances steadied, and how should they be kept?

They are steadied by rests to keep them in a state of repose; they should be well levelled on a solid foundation in glass cases to prevent the influences of draughts of air, weather, heat, dust, etc.

By what means are minute differences of weight determined?

By riders placed on notches on the beam.

When a body is weighed in air and then in water, where is it the heaviest?

When weighed in air.

What is the loss of weight it experiences in water?

As much as the weight of the volume of water it displaces.

What is its specific weight or gravity then?

The relative proportion between its weight in air and its loss of weight in water.

How is the specific gravity of a body heavier than water determined?

By weighing the body first in air and then immersed in water, determining the difference between the two, and then dividing the weight in air by that difference.

If a body is lighter than water how is its specific gravity obtained?

Attach it to another body heavier than water, the loss of weight of which in water has been previously ascertained. Find out the loss in water of both together and deduct the loss of the heavier one from it; the difference will be that of the lighter body alone, with which divide its weight in air.

If a body is soluble in water how is its specific gravity obtained?

By immersing it in another incompatible liquid of known sp. gr., dividing with its loss therein the weight in air, and then multiplying with sp. gr. of the liquid used.

State what a Pyknometer is, and how the specific gravity of liquids is ascertained with it.

A specific gravity bottle having a glass stopper with a capillary opening through it, and usually of a size to contain accurately 1000 grains distilled water at 4° C. If this is well filled with the liquid to be examined, and then dried externally and placed on the scales, the increased or decreased amount of the weight of the same divided by 1000 will give its specific gravity. The weight of the bottle in this operation must be counterpoised or tared; the temperature of the other liquid should be at 0° C. or computed for that degree.

What is the law of Archimedes?

A body immersed in water loses part of its weight equal to the weight of the displaced liquid.

State the position an egg will occupy in pure water and in a saturated solution of sodium chloride, and give the reason for the same.

In pure water it sinks, in saturated Na Cl solution it floats, because the liquid displaced by it in the pure water is lighter than its own weight and heavier in the Na Cl solution, thus buoying it up in the latter.

What instruments are based on the above experiment, and what are they used for, and what are their names according to application?

Hydrometers, used for readily ascertaining the specific gravity of liquids, called, according to their use, urinometers, alcoholometers, lactometers, etc.

How is the scale of hydrometers arranged?

For liquids heavier than water the sp. gr. scale of hydrometers has 1000 on top and the heavier marks below; the hydrometers intended for taking the sp. gr. of lighter liquids is marked 1000 at the bottom of the scale and the lighter degrees are above.

What are urinometers, and what is the extent of their scales?

Hydrometers intended for taking the sp. gr. of urine; marked from 1000 at the top to about 1060 at the bottom.

How is the specific gravity of a liquid observed by a hydrometer?

By partly filling the cylinder with the liquid to be examined, floating the instrument therein, then filling carefully to the top of the cylinder, and reading the mark over the top of the liquid.

How is the quality of good hydrometers ascertained?

By immersing in various liquids of known specific gravity and comparing the marks indicated with those known of the liquids.

Heat—Thermometers.

What is heat?

A condition of matter manifesting itself by physical phenomena and convertible into other forms of force.

When two bodies of different temperature are brought in contact what is the result?

They tend to equalize the amount of heat they are respectively possessed of.

If equal quantities of water of the temperature of 100° C. and of 162° C. are mixed together what will be the temperature of the mixture?

The mean of the two or 131° C.

If equal quantities of water at 0° C. and mercury at 100° C. are mixed, what is the temperature of the mixture, and why?

The mixture will be at 3.3° C., because the heat capacity of water is 1000 to 0.033 for mercury; *i. e.*, the water requires about 33 times as much heat as mercury to elevate it to the same temperature.

What is the individual heat capacity of bodies termed, and how defined?

Their specific heat, or the amount of heat necessary to raise the temperature of a body one degree compared with that required to raise the temperature of the same weight of water one degree.

What is a calorie and what a thermal unit (English)?

The quantity of heat necessary to raise one kilogram of water through one degree centigrade is one calorie (large); that necessary to raise one gram through one degree centigrade is the small or chemical calorie; that required to raise one pound of water through one degree centigrade, one thermal unit = 0.45 calorie (large); one large calorie = 2.2 thermal units.

What is the temperature of a mixture of equal weights of water of 60° C. and of 0° C.?

30° C.

What is the temperature of equal weights of water at 60° C. and ice at 0° C.?

It will remain at 0° C. until all the ice is melted.

Why is this so?

Because the ice absorbs all the heat of the water to accomplish its change from the solid to the liquid state.

What is the heat absorbed by bodies in their change of state, not indicated by the thermometer, called?

Latent heat.

What three states of matter are there?

Solid, liquid, and gaseous.

What is matter composed of?

Molecules and interspaces.

What are molecules?

The smallest physical units of matter.

State the relative condition of molecules in solid, liquid, and gaseous bodies.

In *solids*, the relative positions of the molecules are fixed, and cannot be changed without the expenditure of more or less force. In *liquids*, the relative positions of the molecules are not fixed, they glide past each other coherently, while in *gaseous* bodies the molecules repel each other, and tend to occupy larger spaces.

If a metal ball fitting closely into a ring be heated and then placed in the ring, what is the result?

It will no longer pass through it until it again returns to its ordinary temperature.

What can be said to be the effect of heat on bodies, and what on different forms of matter?

They are expanded by increase of temperature, and contracted by its decrease. The expansion in solids is small, in liquids greater, and for gases the greatest.

As matter is composed of molecules and interspaces, which of the two are thus expanded by heat?

The interspaces, as the molecule is a unit, and cannot increase or decrease in size.

What is a thermoscope?

A glass bulb containing air connected with a narrow tube containing a liquid. Very slight variations of temperature are indicated thus by a change of position of the liquid.

If a bulb of alcohol or mercury or other liquid, to which is attached a narrow tube, is heated, what is the result?

The liquid ascends in the tube.

What are thermometers?

Instruments for measuring temperature.

How are they constructed?

They consist of a bulb of liquid attached to a closed and airless capillary tube; this latter is graduated to indicate the degrees of temperature.

What thermometers are principally used, which preferably, and why?

Alcohol and mercury thermometers; the latter preferably, because the mercury does not wet the glass tube, and does not boil so readily as alcohol.

When are alcohol thermometers to be preferred?

To measure very low degrees of temperature when mercury would freeze.

Which are the principal scales of the thermometer in use?

Fahrenheit and Centigrade (Réaumur also).

How is the Fahrenheit scale graduated?

It is divided into 212 equal divisions or degrees, the lowest of which is a mixture of equal parts of sal-ammonia and snow, and the highest the boiling point of pure water; the freezing point of water on this scale is 32°.

How is the Centigrade scale graduated?

By division into 100 equal parts or degrees, the space of expansion from the freezing point to the boiling point of pure water.

Which is commonly used, and which in chemistry?

The Fahrenheit scale is in common use in this country, the Centigrade scale in chemistry.

How are degrees of Centigrade scale converted into those of Fahrenheit?

As the number of degrees between the boiling and freezing point of water in Centigrade is 100 and in Fahrenheit 212 — 32 = 180, the proportion would be

$$100 : 180 \div \text{degree to be converted} : x$$

by division with 20 it would read

$$5 : 9 \div \text{cent.} : x$$

i. e., the degree to be converted is multiplied with 9, the result divided by 5, and 32 added to the result, as per following formula:

$$\frac{\text{Cent.} \times 9}{5} + 32 = \text{Fahr.}$$

How are degrees of Fahrenheit converted into Centigrade?

From the degree to be converted 32 is subtracted, the difference is divided by 9, and the quotient multiplied by 5, as per following formula: $\frac{\text{Fahr.} - 32}{9} \times 5 = \text{Centigrade.}$

What are clinical thermometers, and what their range?

Thermometers for determining the temperature of the body. Their scale ranges usually from 90°-110° F.

What are self-registering thermometers, and what are indestructible registers?

Thermometers which have a small separate column of mercury, which is shoved up by expansion, but does not contract with the main column, are called self-registering. If these registers are so arranged that they cannot slip down, or be shaken down into the bulb, they are called indestructible.

Why are new thermometers usually incorrect, and what should be done with them?

On account of the contraction of the glass going on for some years, they should for that reason be seasoned at least three years before being marked.

How are thermometers standardized?

They are compared, at their different degrees, with other instruments known to be correct.

MAGNETISM.

What is magnetism?

The force by which loadstone attracts iron.

Give the chemical name and composition of loadstone.

Magnetic oxide of iron: $Fe_3O_4 = FeO.Fe_2O_3$ = Ferrous-ferric oxide.

Describe natural, temporary, and permanent magnets.

Loadstone is a natural magnet. Soft iron, in which magnetism is induced, is a temporary magnet. Steel, when magnetized, becomes a permanent, artificial magnet.

What are magnetic poles and what neutral lines?

The ends of magnetic bars are termed their poles; the middle line between them, which has no power of attraction, is their neutral line.

State what the magnetic axis is.

The shortest lines between the poles.

Which is the north pole and which is the south pole of a magnet in this country?

The pole pointing to the north is the north pole, that pointing to the south the south pole; in France and China the reverse terms are in use.

When particles of soft iron are in contact or influenced by a magnet, what do they become in turn?

Temporary magnets.

Give the action of a magnet on iron filings.

They become, each particle, magnets of more or less strength, and consequently arrange themselves into tufts.

What is magnetic induction?

The production of magnetism in other substances either by direct or indirect contact.

Can magnetism be induced by contact only?

No, it may even act through different media, such as glass, wood, paper, etc.

Does iron alone show magnetic polarity?

Its compounds also, as well as those of nickel and cobalt, give evidence of it.

If a magnet is broken in two or into many pieces, what is the magnetic condition of each piece?

Each piece is a distinct magnet with different poles, as one kind of polarity cannot exist without the other.

What is the hypothesis of magnetism?

That each molecule of a magnet shows magnetic polarity.

If a magnet is evenly balanced or suspended in the middle what position does it assume?

It places itself in the direction of the magnetic poles of the earth.

About what distance are the terrestrial magnetic poles from the true poles?

More or less 1000 miles, varying according to the magnetic axis.

Give the meaning of declination of the magnetic needle.

The angle it makes with the meridian.

What instrument for orientation is based upon the north and south direction of the magnetic needle.

The mariner's compass.

State the result of approaching the north end of the magnetic needle with the north pole of a magnet.

The needle point is repelled, and if the north point is approached by the south pole of a magnet it is attracted.

What law is based upon this?

Like poles repel, unlike attract.

If an unmagnetized steel needle is suspended in the middle and subsequently magnetized, what occurs besides its orientation?

It dips towards the poles, increasing in this respect the nearer it approaches them.

What is this called?

The dip or inclination of the magnetic needle.

What is a horseshoe magnet, and what is its object?

A magnetic bar bent in horseshoe shape, the two poles thus acting by induction upon each other, and increasing each other's power.

What is a magnetic battery or a Germain magnet?

A series of magnetic steel plates joined with their similar poles, making the magnet very powerful.

What is an armature?

A piece of soft iron closing the space between the poles of the horseshoe magnet, intended to preserve its magnetic force, which would otherwise be gradually lost.

Are other bodies besides those known as magnetic affected by magnetism?

Many bodies are so affected, especially the metals, but in much less degree than iron, nickel, and cobalt.

What is paramagnetism?

The power of magnets to direct substances affected by them in an axial position, *i. e.*, parallel with the magnetic axis; such as iron, nickel, cobalt, manganese, chromium, etc.; the substances so affected are called paramagnetic.

What is diamagnetism?

The power of magnets to give certain substances, influenced by them, a direction at right angles to the magnetic axis; such as bismuth, antimony, zinc, tin, etc. These are called diamagnetic.

When two magnetic bars of equal power are joined with unlike poles together what is the attracting force of the two together?

They neutralize each other, and have no attracting force.

What are astatic needles?

Magnetic needles placed so that the north end of the one is counteracted by the south end of the other. They lose their power of orientation.

ELECTRICITY.

[illegible]

[illegible]

[illegible]

[illegible]

[illegible] friction of glass?

[illegible] non-conductors of elec-

[illegible]

What is the law of electric attraction and repulsion?

Bodies charged with the same electricity repel each other; bodies charged with opposite electricity attract each other; or like electricities repel, unlike attract.

How is electricity distributed in bodies?

On the surface, with increased polarity at projections, from which, if sufficiently attenuated, it may even discharge itself into the surrounding air.

How may electricity be produced besides by friction?

By induction; electrified bodies attracting in neighboring bodies, not in contact with them, electricity of a different denomination towards them.

What is the arrangement of simple cylinder electric machines?

They consist of a glass cylinder, which, by a crank, may be rotated against a silk cloth or cushion containing amalgam. Close to this cylinder is an insulated metal globe which presents a number of points towards it. As fast as the positive electricity is exerted in the glass, the negative induced in the globe escapes to it from the points, and leaves the residuary positive electricity in the metallic insulated globe to increase with each rotation.

What is an electrophorus?

An apparatus by which, through difference of potential and induction, considerable electricity may be stored up and discharged. It consists of a metal cover with an insulated handle placed on an electrified layer of shellac or resin; in this way its lower surface becomes positive and the upper negative. If the negative is discharged the more positive accumulates, and if lifted off will give a positive spark.

What is a Toepler-Holtz machine, and upon what principle is it based?

An electrical machine consisting of two upright glass plates, one stationary, and of uneven potential, which by rotation is multiplied, and by induction stores up electricity in the armature of the fixed plate. The principle is similar to that of the electrophorus.

What is an electrometer?

A pith ball attached to a movable lever repelled from a knob electrified with the same denomination, thus indicating the electric tension.

What are Leyden jars, and what batteries?

Instruments for the accumulation of electricity; they consist of glass jars coated inside and outside with tinfoil, the inner being connected with a wire and knob. When the outer connects with the earth and the inner with an electrical apparatus, they become charged respectively with negative and positive electricity, and when so charged may be discharged and give rise to a spark. If several such jars are connected together to increase their effect, they are termed an electric or Leyden battery.

What is the character of electric sparks?

They move in the air in broken lines, as the air offers resistance to their passage by becoming condensed; thus the zigzag course of lightning.

What are the phenomena displayed by insulated electrified persons?

Their hair, when dry, stands on end, and sparks may be drawn from their bodies.

State the medical use of static electricity.

In nervous affections, hysteria, and palsy, the patient being insulated, and sparks drawn from him, then muscular contractions will ensue.

What is thermoelectricity?

The electricity produced when two different metals joined together at each end have their joints unevenly heated; the strength of this depends on the difference of temperature between the two joints.

What are the thermoelectric batteries or piles?

A combination of thermoelectric pairs, principally of bismuth and antimony, or platinum and iron, so that heat may be applied to, respectively, the first, third, fifth, etc., joints, while the others are kept cool.

What is the principal use of thermoelectric piles or batteries?

To indicate slight changes of temperature by its effect upon the needle of the galvanometer.

What is galvanism?

Chemical electricity, also termed voltaism, also dynamic electricity; the electricity produced when two bodies are immersed in a liquid, acting on them with unequal chemical energy.

What are the bodies generally employed for this purpose, and which are the principal ones?

The metals more generally, and zinc always one of them. Thus, zinc and copper, zinc and carbon, zinc and platinum, zinc and silver, etc.

What are such two plates termed, and what a series of them?

A voltaic couple or element; a series of them a voltaic column or pile.

Which is the positive and which is the negative plate?

The one being acted upon more energetically is termed the generating plate and has a *higher potential;* the current flows from it to the *lower potential;* the plate from which the current flows in the liquid being termed *the positive*, while the one to which it flows through the liquid is *the negative.*

When the two plates are joined outside of the liquid by the polar wire, in which direction does the current flow therein?

The outside current flows from the negative plate to the positive. The ends of the wires are termed *poles* or *electrodes*, and their denomination is the opposite from that of the plates they are attached to. Thus the one attached to the negative plate is at its termination called the positive pole or electrode, while the other attached to the positive plate forms the negative pole.

What are the positive and negative poles also called?

The positive pole is called anode, and the negative pole kathode.

If plates of zinc and copper are immersed in dilute sulphuric [illegible] and connected outside of the fluid by a wire, what results?

[illegible] energetic chemical action at the zinc plate. [illegible] will accumulate at the copper plate [illegible] stop the galvanic current passing [illegible] copper plate is then said to be polarized.

What is the polarization of the plates, and how avoided?

[illegible] plates means the accumulation of disen- [illegible] consequent interruption of the cur- [illegible] corrected by mechanical means. [illegible] shown subsequently, by special [illegible] so that the disengaged hydro- [illegible] in the fluid.

Why should the zinc plates be amalgamated?

[illegible] of currents caused by the impurities [illegible] present therein.

What are galvanic elements and what batteries?

[illegible] plates of different potential, im- [illegible] held in a stone, glass, or rubber vessel. [illegible] number of them, properly arranged [illegible] galvanic battery.

What is Daniell's element? what its advantage? about what [illegible] electromotive force? and what is the object of the arrangement?

[illegible] containing a saturated solution of copper sul- [illegible] copper cylinder. Immersed in the copper [illegible] cylinder, is a porous cup filled [illegible] containing a zinc cylinder. Its [illegible] of special advantage, and it is for [illegible] force is accepted as a unit or [illegible] chemically to overcome [illegible] hydrogen from the zinc passes to the [illegible] copper sulphate solution, substituting [illegible] of copper of the $CuSO_4$, forming thus H_2SO_4; the liberated copper is deposited on the outside copper cylinder, while the newly-formed H_2SO_4 passes into the porous vessel to act on the zinc.

Describe the arrangement of a Grove's element.

A two-fluid cell, containing, outside, zinc, immersed in dilute sulphuric acid; inside the porous cup is a platinum slip in nitric acid. The hydrogen evolved at the zinc, and passing to the platinum, decomposes the nitric acid, thus also chemically preventing polarization.

What is a Bunsen's element?

A two-fluid cell, arranged similar to Grove's, with a compressed gas retort carbon being substituted for the platinum. The object and principle are the same as in the former.

What is a Smee's element, and how is polarization prevented by it?

A single fluid cell, in which a platinum sheet is immersed in dilute sulphuric acid between two zinc plates. The platinum sheet is covered with small fragments of platinum, or a silver plate covered with finely divided platinum may be substituted for it; the platinum particles *mechanically* aiding the disengagement of the hydrogen from the platinum.

Describe the arrangement of a Grenet cell.

A one-fluid cell, containing two fixed carbon plates, immersed in a battery fluid of sulphuric acid and potassium bichromate. Between the carbons is a zinc plate which can be lowered into the fluid to set it in action. The object of the potassium bichromate is to form chromic acid, which oxidizes the hydrogen into water.

Give the arrangement of a Leclanché element.

A porous cup containing a carbon rod, surrounded by pieces of peroxide of manganese and gas carbon. Outside the porous cup is a saturated solution of ammonium chloride, and immersed in it a rod of zinc.

What is a Calland's or gravity element?

A modification of Daniell's element, doing away with the porous cup. It consists of a star-shaped copper plate at the bottom of the vessel, which is surrounded by pieces of copper sulphate; it is immersed in a saturated solution of the same substance. The upper half of the vessel is occupied by dilute sulphuric acid, which, by the difference of density, floats on the copper solution, and contains suspended in it a star-shaped arrangement of zinc. Its action is the same as in the Daniell, and is very constant; it is principally used in telegraphy.

What is the electrical tension or potential?

The electricity accumulated at certain points.

What is electromotive force?

The amount of electricity generated by an electrical battery. It is generally accepted as the difference of potential of the two plates.

What is the electromotive series of metals?

The arrangement of metals according to their electrical deportment; the most electropositive being at one end and the most electronegative at the other, as follows: 1. Zinc. 2. Cadmium. 3. Tin. 4. Lead. 5. Iron. 6. Nickel. 7. Bismuth. 8. Antimony. 9. Copper. 10. Silver. 11. Gold. 12. Platinum. 13. Graphite. Thus iron in dilute sulphuric acid is electronegative to zinc but electropositive to copper.

What is the law for the electromotive force between two metals?

That the electromotive force between two metals is equal to the sum of the electromotive forces between all the intervening metals.

What is a volt?

The unit of electric pressure or electromotive force. It is about the electromotive force of one Daniell's element.

What is generally understood by the electric current?

The current of electricity passing through the wire.

What is the direction of the outside current?

From the electronegative plate (carbon or copper), to the electropositive (zinc).

On what does the current strength depend, and by what is it diminished?

The current strength depends on the amount of electromotive force, and is diminished by the resistance which it encounters.

How may the relations then be stated?

The current strength is directly proportional with the electromotive force and inversely with the resistance.

What is the resistance, and what two resistances do we encounter in a galvanic cell?

The force opposing the flow of the current is the resistance; that existing in the liquid between the plates is termed internal resistance; that diminishing the conductivity of the wire is called external resistance.

What is the law governing the resistance of a conducting wire?

The resistance is inversely as the cross section, and directly as the length of a conductor.

What is the unit of resistance?

The "Ohm;" the resistance offered by a column of mercury, 104.81 centimetres long, one square millimetre in section at 0° C.

What is the unit by which current strength is computed?

The ampère; the current strength of one volt of electromotive force passing through a circuit having one Ohm resistance.

How may the current strength be computed?

By the Ohm's law; the current strength is equal to the electromotive force divided by the resistance, as per following formula: $C = \frac{E}{R}$

Of what advantage is the application of the Ohm's law in galvanism?

The advantageous coupling of the elements with a view to greater intensity or quantity.

When is the combination best for producing intensity?

By increasing the internal resistance; *i. e.*, coupling the different elements separately as such, as needed in galvanization of muscles and nerves, and also in electrolysis.

How are the elements to be coupled for quantity?

By combining all the zincs together and also the carbons, thus diminishing internal resistance; this is the combination employed for galvano-cautery and lighting purposes.

How is electric light produced for medical purposes?

By passing a galvanic current of quantity through a carbon filament or platinum wire contained in an airless glass globe, when the resistance to the current will produce the luminous effect.

What is the principle of the galvano-cautery?

A thin platinum wire by the passage of a quantity of electricity will be intensely heated, and can then be applied for cautery purposes.

What is the effect of an electric current passing around a magnetic needle?

It will deflect the needle from its position.

In which direction is the needle deflected by the galvanic current?

This depends upon the direction the current passes, and if above or below the needle. For ready comprehension a person may imagine himself floating in the current with the head in direction of the current and facing the needle, when the north end of the needle will be deflected to the left.

What is a galvanometer?

An instrument so arranged as to indicate by the deflection of the needle the existence, direction, and intensity of currents. It is generally composed of astatic needles and multipliers.

What instruments are employed to indicate the current strength for medical purposes?

Those indicating the amount of ampères, or rather milli-ampères, passing through the circuit. They are termed ampère or milli-ampère-meters.

What is the effect of an electric current passing around soft iron?

It makes a very powerful temporary magnet.

When the current is broken or opened, and when made or closed, what takes place, and to what purpose is it applied?

The iron is magnetized when the circuit is closed, and becomes demagnetized when opened. On these phenomena the electric telegraph is based.

What is Faradism?

The electricity developed by induction from the galvanic current.

How can this be illustrated?

By placing a wire, *not* connected with any battery, close and parallel with a wire connected with a galvanic battery; there will be an electrical manifestation in the former every time the galvanic current is made or broken.

How does the induced current make itself manifest, and in what direction does it flow?

It is not a steady current, deflecting the galvanometer needle only at the time the primary current is closed or open. When the current is closed, it flows in an opposite direction to the primary current, but on breaking it is reversed.

Has the faradic current chemical properties, and if not, why not?

It has no chemical powers, because it is a to and fro current, and its action in one direction is neutralized by the return flow.

How may very powerful electric manifestations of the induced current be developed?

By multiplying the secondary wire.

What are the instruments for this purpose, and component parts?

Ruhmkorff coils; consisting of a primary coil, an iron core therein, an automatic breakpiece or interrupter, a secondary coil, and an accumulator or condenser for the extra current.

Which is the longer, the primary or secondary coil?

The secondary, which is on the outside, and often contains many miles of wire.

What is the object of the iron core?

To attract the breakpiece when it becomes magnetized.

What is the breakpiece?

A spring connecting with the primary wire by a small plate of platinum, and having a small hammer end, which is attracted when the core is magnetized; it thus breaks the current, and springs back when the core is demagnetized, when the current is again made.

What does the condenser consist of, and what is its object?

It consists of layers of glass covered with tinfoil, acting on the principle of a Leyden jar. It accumulates and condenses the extra current.

On what principle are medical faradic batteries constructed?

Similar to that of the Ruhmkorff coil with a Grenet cell to furnish the primary current.

What measures should be adopted to insure the good working of a faradic battery?

The interrupter should be kept free from rust and corrosive material; all connections should be tight, insulations should be complete, and the battery fluid should not be allowed to dry out, or become decomposed.

When the purely faradic current is employed, does it matter how the poles are disposed of?

No; as the current goes both ways.

What is the principal use of the faradic current in medicine?

To excite nerves or bring about muscular contractions, both for diagnostic and therapeutic purposes.

What is the use of the constant galvanic current in medicine?

For nerve stimulation, for cautery, and for its chemical effect.

What is the chemical effect of the galvanic current, and what is it termed?

The chemical decomposition of compounds in a fluid state; it is termed electrolysis.

What takes place when water is subjected to electrolysis, and how does it take place?

It is decomposed into its constituent elements, hydrogen and oxygen. The hydrogen accumulating at the negative (—), the oxygen at the positive (+) pole or electrode.

What are substances called subjected to electrolysis? what the results? what are those which go to the positive and those that go to the negative pole?

The products of decomposition are termed IONS; the subjects for electrolysis are electrolytes; those which go to the negative pole, the kathode, kathions; those which go to the positive pole, the anode, anions.

What takes place if a galvanic needle is inserted in the human body?

The salts and fluids are decomposed; alkalies and hydrogen go to the negative; oxygen and acids go to the positive pole.

What is electrolysis used for in medicine?

For removing tumors, hairs, nævi, warts, etc.

In the electrolysis of tumors, what needle should be inserted into them, which in aneurisms, and why?

The electronegative in tumors, the electropositive in aneurisms; because the alkalies at the negative pole liquefy the tissues, while the acids at the positive pole condense them, and coagulate the blood.

CHEMISTRY.

What is chemistry?

That branch of physical science which treats of the composition of matter.

What are physical, what chemical changes?

Physical changes are those which do not affect the composition or construction of the molecule ; chemical changes, those altering its character, and thus changing matter itself.

What is chemism?

That form of attraction which takes place between atoms.

What is a molecule?

The smallest particle of matter that can exist in a free state, and cannot be divided without losing its character.

What is an atom?

The chemical unit of matter produced by the breaking up of the molecule.

How may matter be subdivided?

Into simple or elementary and compound matter ; termed relatively elements and compounds.

Define simple or elementary and compound matter.

Matter made up of molecules, containing like atoms, is elementary ; that whose molecules are made up of dissimilar atoms is termed compound.

How many elements and therefore different kinds of atoms are known?

At the present time about sixty-six are definitely known as such.

How are atoms designated in chemical notation? example.

By symbols, consisting of the first, or the first and some other letter of their Latin name. H for hydrogen, B for bismuth, Pb for lead (Plumbum), Hg for mercury (hydrargyrum), etc.

What do symbols express besides the atomic character?

The atomic weight.

What is atomic weight?

The relative weight of an atom in comparison with the hydrogen atom as a unit. It also expresses the smallest quantity of an elementary substance capable of entering into the formation of a chemical compound.

In which way is the quality of the combining power of an atom expressed?

By its electrical polarity in relation to another atom. Thus, atoms are either *electropositive*, *i. e.*, accumulating at the electronegative pole, or *electronegative*, *i. e.*, accumulating at the electropositive pole during the electrolysis of a compound.

Is the electro-chemical character of atoms definite or relative?

It is relative in so far that an atom is electropositive towards some, electronegative towards others, but it is definite in these relations; thus, the metals are electropositive to the metalloids, and these are electronegative to the former.

What is the quantity of atomic combining power?

The fact that some atoms can combine with one atom of hydrogen, and others with two, three, and more of it, demonstrates the quantitative combining power of atoms.

What is then the equivalence of an atom?

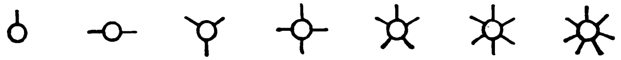
The quantity of its combining power expressed in hydrogen units, or the number of hydrogen atoms it can combine with, or be exchanged for.

How is the equivalence of atoms expressed, and how is it written in notation?

Either by the use of Greek numerals, as monads, dyads, triads, tetrads, pentads, hexads, and heptads, or by Latin numerals, as univalents, bivalents, trivalents, quadrivalents, quinquivalents, sexivalents, and septivalents. In chemical notation this is expressed by placing Roman numerals above, and to the right of the symbol: H^{I}. O^{II}. N^{III}. C^{IV}. As^{V}. S^{VI}. Cl^{VII}.

How may the equivalence of the atom be graphically represented?

By illustrating the atom as a small ring or dot or symbol, and the equivalence by lines radiating from it; these lines are termed bonds, as follows:—



When an atom combines with another in several proportions, what characteristic series appear, and into what two groups are they accordingly classed?

Its higher compound always increases by two, as for instance, 1, 3, 5, and 7, or 2, 4, and 6. These two can never interchange, and the series whose equivalents are in even numbers are termed *artiads*, while the odd are called *perissads*.

In which way are multiples of atoms expressed in chemical notation?

By placing small Arabic numerals to the right and below the symbol, for instance, Cl_2, O_3, As_4.

What do groups of atoms represent, and what is their chemical notation termed?

They represent a molecule, and their designation in chemical notation is termed a *formula*; for example, $NaCl$, H_2So_4, etc.

How are multiples of molecules expressed?

By inclosing their component symbols in parentheses and placing a small Arabic numeral outside to the right and below, or by placing a larger numeral before the molecule without parentheses; thus, $(NaCl)_2 = 2\ NaCl$.

In which way is a reaction to take place between two chemical bodies designated, how its completion, and how the product or products?

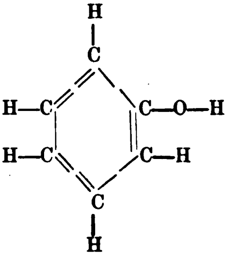
Before the reaction takes place they are separated by a plus sign (+), the union complete by an equation sign (=), and the product by its formula, or, if more than one, they are separated by plus signs; example, $NaOH + HCl = NaCl + H_2O$.

What are empyrial, what rational, and what graphical formulæ?

An empyrial formula is one expressing the kind and number of atoms in the molecule. A rational formula indicates, besides this, the arrangement of the atoms in the molecule. The graphical are simply illustrations of rational formulæ.

C_6H_6O
Empyrial formula.

$C_6H_5.OH$
Rational formula.



Graphical formula.

What two kinds of molecules can be chemically distinguished?

The elementary molecules composed of atoms of the same kind, and the compound, composed of atoms of dissimilar elements.

Give the definition of molecular weight.

The sum of the atomic weights of a molecule.

How may compound molecules be classified?

Binary molecules in which the atoms unite directly, and *ternary* molecules in which the atoms are indirectly united.

Of how many kinds of atoms are binary molecules always composed?

Of only two different kinds of atoms.

What is the rule for naming binary molecules?

As they must be composed of electropositive and electronegative elements, the electropositive is always placed with its full termination first, while the electronegative has its terminal syllable changed to "ide"; thus, potassium chloride, hydrogen sulphide, calcium fluoride, etc.

When an electropositive element unites with the electronegative in more than one proportion how are the two compounds distinguished by name?

By the affix of "ic" to the one and "ous" to the other; examples: mercuric oxide, mercurous oxide; ferric chloride, ferrous chloride.

When there are other compounds by change of valence how are they expressed by name?

The electropositive of the lower receives before its name the affix of "hypo" and the highest that of "per"; thus, hypochlorous oxide and per-chloric oxide.

How are multiples of the same kind of atoms in the name of the compound molecule expressed?

By the prefix of Greek numerals, such as carbon dioxide, sulphur trioxide, nitrogen tetroxide, arsenic pentoxide. Sometimes the multiple of the electropositive is similarly expressed, as in di-nitrogen tetroxide, di-arsenic pentoxide.

What are compound radicals?

Unsaturated molecules, not existing in a free state, but capable of uniting directly with an atom or a similar compound to form saturated molecules.

What is the rule for naming them and their compounds with atoms?

That they end in yl; example: HO—Hydroxyl; but some, as amidogen NH_2—Cyanogen CN—differ in this. Their compounds with atoms are subject to the same terminology as binary molecules.

What is a ternary molecule?

One in which two dissimilar atoms are united by means of a third having linking functions.

Which are the atoms having linking functions?

The principal one is oxygen, but sulphur, selenium, and tellurium also possess this function.

What three classes of ternary molecules are distinguished?

Acids, bases, and salts.

What two kinds of acids do we distinguish?

Binary or hydracids, and ternary or oxyacids.

Give the definition of an acid.

A compound of hydrogen with an electronegative which can give up its hydrogen for the metal of a base to form a salt.

How is an oxyacid constituted?

It is a compound in which hydrogen is united by oxygen to an electronegative. $H—O—\overset{-}{R}$.

What is a base?

A compound containing hydrogen united by oxygen to an electropositive. $H—O—\overset{+}{R}$.

What is a salt?

A compound in which one or more electropositive atoms are united by oxygen to one or more electronegative atoms. $\overset{-}{R}—O—\overset{+}{R}$.

What are the characteristic properties of bases, and what of acids?

Bases turn turmeric paper brown, and reddened litmus paper blue; acids turn blue litmus paper red.

Upon what type may the above be said to be formed?

The water type, because by replacing one H of H-O-H with $\overset{-}{R}$ an acid is formed, by $\overset{+}{R}$ a base; by replacing both H, one with $\overset{-}{R}$ the other with $\overset{+}{R}$, a salt results.

What names are applied to the bases?

Considered as compounds of the radical hydroxyl, they are named hydroxides or hydrates; thus, KOH potassium hydrate, NaOH sodium hydrate.

What terminal endings are affixed to the acids?

Acids are expressed by the affix of "ic" to the abbreviated electronegative. The hydracids besides receiving the prefix "hydro," the higher acids of an acid, terminate in "ic," the lower in "ous." Thus, HCl hydrochloric acid, H_2SO_4 sulphuric acid, H_2SO_3 sulphurous acid.

What are the names of salts according to the acids used in their formation?

Hydracids form binary compounds, ending in "ide;" "ic" acids form "ate" salts; "ous" acids form "ite" salts; "hypo" acids form hypo-ites; "per" acids form "per-ates;" thus, hydrochloric acid forms chlorides; sulphuric acid forms sulphates; sulphurous acid forms sulphites; hypochlorous acid forms hypochlorites; perchloric acid forms perchlorates.

What expresses the basicity of acids and the acidity of bases?

The basicity of acids depends on their amount of replaceable hydrogen, and the acidity of bases on their number of hydroxyl groups; example, HNO_3 monobasic acid, H_2SO_4 dibasic acid, etc. KOH monoacid base, $Ca(OH)_2$ diacid base.

What are normal, acid, basic, and double salts?

Normal salts, those having neither acid nor basic hydrogen in excess; acid salts, those containing basic hydrogen in excess; basic salts, those having acid hydrogen in excess; double salts, those containing two or more different positive atoms. Thus, normal salt, $Ca_3(PO_4)_2$; acid salt, NaH_2PO_4; basic salt, $PbOH(C_2H_3O_2)$; double salt, NH_4MgPO_4.

What is the ammonia type, and the terms of its compounds?

The type of compounds formed by substituting the hydrogens of ammonia NH_3; the substitution of H by an electropositive atom or radical forming an "amine;" the substitution of H by an electronegative atom or radical forming an "amide;" while the substitution of an H by an electronegative and another by an electropositive, yields an alkalamide.

What are the further denominations of amines and amides?

According to the number of H substituted they may be mon-animes, di-amines, and tri-amines, or mon-amides, di-amides and tri-amides; the names of the electronegative or electropositive atoms or radicals displacing the H, being placed between the Greek numeral and the words amine or amide. If more than one of the NH_3 group enter into the compound, the substituting radicals are placed before the Greek numeral which are used according to the number of N left. Thus, ethylamine, di- or tri-ethylamine, mono-di- or tri-acetamide; in the last case, however, carbonyl-di-amide, etc.

What are the relative volumes of the molecules of all bodies in a gaseous state?

The volumes of molecules of gases are alike; or equal volumes of gases contain equal numbers of molecules.

How do gases combine?

Volume for volume when both are monads, two and one when monad and dyad, three and one when monad and triad, etc.

How many volumes result in all these cases?

Two volumes or two molecules, if each combining volume is one molecule.

When one molecule of hydrogen and one molecule of chlorine unite, what is formed?

Two molecules of HCl.

What does this prove?

That, as two molecules of HCl were formed, each contains one atom of H and one of Cl, the molecule of hydrogen and of chlorine contain each two atoms.

What is stoichiometry?

The computation of the weights of bodies entering into chemical combinations and their results.

How are the molecular weights of chemical bodies determined?

By adding together the atomic weights of the component atoms. Thus H_2SO_4—

$$\begin{array}{r} 2H = 2 \\ S = 32 \\ 4O = 64 \\ \hline \text{Total} = 98 = \text{molecular weight of } H_2SO_4. \end{array}$$

When HNO_3 unites with KOH, what results? formula?

$HNO_3 + KOH = KNO_3 + H_2O$.

What does this equation also stand for in weight units?

$$\frac{1+14+48}{63}+\frac{39+16+1}{56}=\frac{39+14+48}{101}+\frac{2+16}{18}$$

How may the elements be classified for convenience of study?

Into metals and non-metals, which are again grouped according to their valences, electro-chemical relations, as well as physical and chemical characters; hydrogen and oxygen are grouped by themselves as typical elements. Thus—

NON-METALS.

Group I.	Hydrogen and oxygen.
Group II.	*Electronegative monads*, or *Chlorine group.* Fluorine, chlorine, bromine, iodine.
Group III.	*Electronegative dyads*, or *Sulphur group.* Sulphur, selenium, tellurium.
Group IV.	*Electronegative triads*, or *Nitrogen group.* Nitrogen, phosphorus, arsenic, antimony (bismuth, see metals).
Group V.	Boron.
Group VI.	*Electronegative tetrads* or *Carbon group.* Carbon, silicon.

METALS.

Group I.	*Alkali metals.* Lithium, sodium, potassium, rubidium, caesium (ammonium).
Group II.	*Metals of the alkaline earths.* Calcium, strontium, barium.
Group III.	*Magnesium group.* Magnesium, beryllium, zinc, cadmium.
Group IV.	*Lead group.* Lead, thallium.
Group V.	*Copper group.* Copper, silver, mercury.
Group VI.	*Yttrium group.* Yttrium, erbium, terbium, yterbium, scandium, decipium, lanthanum, cerium, didymium.

Group VII. *Aluminium group.*
Aluminium, indium, gallium.
Group VIII. *Iron group.*
Manganese, iron, cobalt, nickel.
Group IX. *Chromium group.*
Chromium, molybdenum, tungsten, uranium.
Group X. *Tin group.*
Tin, titanium, zirconium, thorium.
Group XI. *Bismuth group.*
Vanadium, bismuth, tantalum, niobium.
Group XII. *Platinum group.*
Gold, platinum, palladium, rhodium, iridium, ruthenium, osmium.

Hydrogen.

What is hydrogen, and what its properties?

A colorless, odorless, tasteless elementary gas, rarely found free in nature. Symbol H, atomic weight 1, valence^{I}, molecular weight 2; one liter at 760 mm. pressure and 0° C. weighs 0.08958 grams = 1 crith. It is combustible, but not a supporter of combustion. A mixture of H and O will explode violently when lighted, forming water.

How can it be demonstrated that it is lighter than air?

A balloon or soap-bubble filled with it will rapidly ascend. It can be readily transferred by pouring it from one inverted vessel into another from below upwards, displacing the air in doing so.

What is its diffusibility?

It is highly diffusible, penetrating through porous bodies with ease, and diffusing through membranes.

Is hydrogen under all circumstances and conditions a gaseous body?

It can be reduced to the liquid state by cooling to —140° C., and under a pressure of 600 atmospheres. It then resembles a steel-blue, non-transparent fluid, somewhat like mercury, and upon evaporation even solidifies.

How can the formation of water by the union of H and O be proven?

If a flame of hydrogen is allowed to burn in a cool glass cylinder, this will soon be found covered with dew.

How can hydrogen be prepared?

By electrolysis of water, by the action of some metals on water, and by the action of zinc or iron on sulphuric or hydrochloric acid.

What is the result of the electrolysis of water in the Hoffmann's tubes, and how is the presence of H proven?

When acidulated water is subjected to electrolysis, the H will accumulate in the tube containing the negative electrode, the O in that containing the positive electrode. There will be besides a definite relation between the volumes of the two gases so liberated, that of H being twice that of O, showing the composition of water as H_2O. The presence of H can be proven by collecting the gas in a test tube, and burning it, water resulting.

How can hydrogen be prepared from water by the action of metallic potassium or sodium?

Sodium or potassium, by superior chemical attraction for oxygen, displaces at ordinary temperature one H, and unites with the residuary HO, as per following formula:—

$$H_2O + Na = NaOH + H.$$

Can other metals produce the same result?

Iron at red heat will do the same, uniting with O and liberating H.

What is the most common process for obtaining hydrogen for experimental purposes?

The action of zinc or iron on sulphuric or hydrochloric acid, the metal replacing the H of the acid and setting this free to be collected, as per following formula:—

$$Zn + H_2SO_4 = Zn\ SO_4 + 2H.$$

What other process is employed for obtaining H in Fleitmann's test?

The action of aluminium metal on sodium- or potassium-hydrate at ordinary temperature, or that of zinc at the boiling point, as follows: $Al + 3KOH = K_3AlO_3 + 3H$.

For what purposes is hydrogen in its nascent state used in chemistry?

As a reducing agent, *i. e.*, to take away from and unite with the oxygen of other bodies.

What is the physiological effect of inhaling hydrogen, and why?

It produces a higher pitch of the voice on account of the more rapid vibrations of the vocal cords in a less dense atmosphere.

Oxygen.

What is oxygen? Its properties?

A colorless, odorless, tasteless, elementary gas. Symbol, O, a. w. 16, valence^{II}, m. w. 32; one litre weighing at 0° C. and 760 mm. 1.43 grams. It is liquefied at —130° C. and 470 atmospheres pressure; it is slightly soluble in water (about 3 per cent. at 15° C.). It is a supporter of combustion, but not combustible. It unites with all the elements excepting fluorine, forming with them compounds termed "oxides."

What is the process termed when oxygen unites with another element, and amidst what phenomena does it usually take place?

Oxidation, which, if it takes place rapidly, is generally accompanied by development of heat and light, and is then termed combustion.

Where is oxygen found, and in about what proportions?

It is the most abundant element in nature, existing free in the atmosphere, and in combination with other elements; it composes about two-thirds of the entire globe.

How may oxygen be prepared?

By heating mercuric oxide to a high temperature it is decomposed into mercury and oxygen. $HgO = Hg + O$.

How is it prepared from potassium chlorate?

By heating the coarsely powdered $KClO_3$ and collecting the escaping gas; as this gives rise to irregular and violent evolution of the gas, about one-fourth of its weight of powdered manganese dioxide is mixed with it, which causes the more even liberation of the gas and at a lower temperature; the manganese dioxide, however, takes no chemical part in the process. $2KClO_3 = 2KCl + 3O_2$.

In what other processes is oxygen liberated?

In the electrolysis of water, also by the action of sunlight upon the leaves of plants.

What takes place if a piece of magnesium wire is ignited, and what is the product?

It deflagrates, emitting a very bright light, leaving as a white ash the magnesium oxide.

If a glowing charcoal ember, ignited sulphur, phosphorus, or a heated steel wire, is immersed in a jar containing oxygen what takes place, and what are the results?

They deflagrate rapidly, giving rise to heat and light, leaving as results the oxides of the different substances used. The carbon produces CO_2, the sulphur SO_2, the phosphorus P_2O_5, the iron Fe_2O_3.

What is the oxy-hydrogen flame, and how applied to the lime light?

A flame produced from burning oxygen and hydrogen from a special burner. It is not luminous but very hot, melting even platinum, etc. By exposing to it a piece of lime, this becomes incandescent, and emits a bright white light.

Is slow oxidation, such as the rusting of iron in the air, different in its result from rapid oxidation or combustion?

They are identical processes and yield the same results; the heat given off in rapid combustion is also given off, but apparently insensibly, in the slow oxidation.

What chemical process is going on in the burning of coal oil, candles, etc.?

An oxidation of their component parts; their carbon forming carbon dioxide CO_2, and their hydrogen water H_2O.

What is the part oxygen takes in the physiological process?

It is carried by the hæmoglobin of the red blood corpuscles to the tissues, where it unites with their carbon and hydrogen, forming carbon dioxide and water; the former of these as a waste product is given off by the lungs; the heat liberated by this oxidation produces either animal heat or is converted into the other physiological forces.

Why are inhalations of oxygen of no benefit in the treatment of disease?

Because the corpuscles cannot take up more or in a different dilution than formed in the atmospheric air. It is proven that animals when kept in an atmosphere of oxygen, do not exhale more CO_2 than when kept in air.

Ozone.

What is ozone? Its properties?

Condensed oxygen; triatomic molecules of oxygen, O_3, of a density of 24 (H1), m. w. 48. It possesses a penetrating chlorine odor and a bluish color; it is coercible at high pressure and low temperature yielding drops of indigo blue color. At 300° C. it becomes diatomic oxygen. It is chemically very active, oxidizing other bodies readily and bleaching organic coloring matter; it is absorbed without change by oil of turpentine and other essential oils.

What may ozone also be said to be?

An allotropic form of oxygen, *i. e.*, a substance which, though qualitatively of the same elementary composition, has different physical and chemical properties, owing to the difference of its molecular structure.

How is ozone prepared?

1. It forms when phosphorus is exposed to moist air or oxygen. 2. By the addition of small quantities of potassium permanganate or barium peroxide to cold sulphuric acid. 3. By an electric discharge through the air or oxygen.

How is it best prepared?

By the silent discharge of a powerful current from a Ruhmkorff coil through a Siemen's induction tube, through which freshly prepared oxygen is allowed to flow.

How is ozone recognized?

By its action on potassium iodide starch paper; as it decomposes the KI into K and I, the I turns the starch blue. Tincture of guaiacum is turned blue and lead acetate brown by O_3.

Hydrogen peroxide answers the same test, but O_3 in addition blackens bright strips of silver.

What influence has ozone on epidemic diseases?

It is said to arrest them by oxidizing the organic material giving rise to them.

When and where is ozone found?

It is found in the air, especially after thunder storms, and abounds in high latitudes, the seashore, etc.

What is the effect of inhaling air rich with ozone on the respiratory organs?

It irritates them, causing coryza and even hæmoptysis.

Compounds of Hydrogen and Oxygen.

Water.

How can the composition of water be proven?

By analysis and synthesis.

What is analysis and what synthesis? how can they be applied to water?

Analysis means the decomposition of a molecule into its component atoms, and synthesis the recomposition of the constituent atoms to form the molecule. Electrolysis effects the analysis of H_2O into 2H and 1O; and if two volumes of H and one of O are mixed, and united by an electric spark passing through them, water is formed.

What is water? Its properties?

A compound of H and O; formula H_2O, m. w. 18, density 9, sp. gr. 1; solidifies at 0° C.; boils at 100° C. It is a limpid, colorless, odorless, and tasteless liquid. Its maximum density is at 4° C = 39, 2° F., at which point its liter weighs 1000 grams. It is a poor conductor of heat and electricity. At 0° C. it solidifies, and is then known as ice; at 100° C. it boils and assumes a gaseous form, known as steam. Its solvent powers are very great.

What are the chemical properties of H_2O?

It is chemically very active, uniting with the oxides of the electropositives to form bases ($CaO + H_2O = Ca(OH)_2$), **and with** the oxides of electronegatives to form acids ($CO_2 + H_2O = H_2CO_3$).

How may water influence the molecular structure of crystalline bodies?

It enters into the molecular structure of many crystalline bodies without forming a chemical part thereof; when this is given up by them spontaneously they are termed *efflorescent*, and when they attract more from the atmosphere and liquefy, they are called *deliquescent*. When containing no H_2O molecule, a body is called *anhydrous*.

What is distillation, what sublimation, and what distilled water?

Distillation means the volatilization of liquids, condensing and recovering their vapors in special apparatus. Sublimation is the same process applied to volatile solid bodies. Distilled water is the water purified by the former method for chemical and other purposes; it is however not absolutely pure.

Define the term potable, hard, temporary-hard, permanently-hard, and soft water.

Potable is water when suitable for drinking purposes; hard is water when it contains calcium or magnesium salts, and does not lather with soap; when it contains the carbonates of calcium or magnesium in solution and removable by boiling, it is temporarily hard; when the hardness is due to other soluble salts of Ca or Mg not removable by boiling, it is permanently hard. Soft water contains little or no mineral salts in solution.

What is the purest natural water, and what does it usually contain?

Rain- or snow-water, if not contaminated in collecting; it contains little solid matter, except traces of ammonium nitrite and nitrate, but some oxygen, nitrogen, and carbon dioxide in solution.

What is the principal contamination to guard against in rain-water for potable purposes?

Lead from roofs or pipes, as the nitric and nitrous acids, as well as nitrates, render soluble compounds with lead.

Which waters contain, besides solid ingredients, notable quantities of organic material?

River waters, especially those draining marshes or running sluggishly through marshy bottoms.

Is organic material admixed to water always deleterious, and when is it?

In itself organic material is not injurious, but as it is a soil for disease germs it is objectionable; when it arises from draining off animal excreta it may contain disease germs which render it dangerous to health. Thus sewage contamination of water is apt to contain germs which can proliferate in organic material, and breed disease.

What other admixture is found in river water, and of what importance is it?

Rivers running through alluvial soil may through freshets also contain in their waters suspended matter, which, when of mineral origin, is of no especial significance, but if it arises from organic source may become dangerous to health.

How may river water be purified?

By storage and sedimentation, allowing undissolved mineral and organic matter to be deposited; by aeration, so that oxygen of the atmosphere oxidizes the organic matter; by filtration, restraining undissolved particles by interposed gravel beds; finally, by dilution from additional pure sources into its course.

What precaution should be observed in selecting a water supply from rivers?

To select the source of supply sufficiently far away from large cities, and as far as possible below any places of habitation or factories emptying their refuse into it.

What objection is there to well-water?

That it contains surface water drained from cesspools, and that it is impregnated with both organic and inorganic material. The deeper the wells are, the danger from this source diminishes.

What are deep and artesian wells, and the character of their water?

Wells sunk through impermeable strata, receiving their water from large distances, or from the underground flow of rivers. Their water is usually free from organic material, but abundant with mineral ingredients.

What are the source and character of spring-water?

Springs generally receive their supply from rain-water which has filtered into deeper strata, and has found its outlet below its original level. It is generally cool and fresh, containing little organic matter, but abundant mineral material.

What may indicate sewage contamination of water, and what amount thereof is permissible in potable water?

Sodium chloride and other chlorides may indicate sewage contaminations, but are no evidence thereof. Potable water should not contain more than two grains of it to the gallon. If more, the character and amount of organic material should be determined.

Is there any chemical process giving the amount of organic material contained in water?

No; the organic material in water can only be arrived at comparatively by either converting it by an alkaline potassium permanganate solution into ammonia, and determining this with the Nessler's test, or by determining how much potassium permanganate solution is necessary to oxidize it, and comparing this with the amount of oxalic acid necessary to the same end.

What process may be employed to determine the amount of organic material?

The biological test in which sterilized gelatine solution is inoculated with the water to be tested; the number of colonies of bacteria developed are then counted and compared with those developed from known pure water.

How is the amount of chlorides in water determined?

By testing the water either directly or after concentration with a volumetric solution of silver nitrate, using potassium chromate as an indicator.

How is this done?

One hundred c.c. of the water are placed in a beaker glass, a few drops of the potassium chromate solution are added to render it yellowish. The mixture is rendered slightly alkaline, and then from a burette the silver nitrate solution (4.79 grams per liter) is dropped into it until the water turns faintly orange-red. Each c.c. of the silver solution so used represents 0.001 chlorine in 100 water or 0.01 in the liter.

What does the presence of nitrites in water indicate?

The decomposition of organic nitrogenized material, and any other but rain-water, containing them, should be regarded with suspicion.

How can small amounts of nitrites in water be readily detected?

By adding to it a solution of diphenylamine in pure strong sulphuric acid. If nitrites are present a blue color will be developed. Also by adding to the water to be examined a few drops of H_2So_4 and then some starch-water, and lastly a few drops of KI solution. If the starch turns blue nitrites are present.

What is indicated by detecting in water an excess of chlorides and also nitrites?

That it is contaminated with sewage.

Is an excess of chlorides alone, without organic admixture, or of nitrites alone without chlorides sufficient to condemn a water?

No, as water may, for instance near the ocean, contain a greater amount of chlorides, and rain-water generally contains nitrites.

What are the best means for purifying water?

Filtration to remove suspended matter and boiling; because this destroys the disease germs and corrects temporary hardness.

How is water tested for lead?

By evaporating a certain amount, treating the residue with HNO_3, evaporating the excess of HNO_3, dissolving the residue in a little distilled water and passing through it a current of hydrogen sulphide. If lead is present (other metals of this group being excluded), a brownish-black precipitate will be noticed; when lead exists in notable quantities, the water may be tested direct by hydrogen sulphide or an addition of ammonium sulphydrate.

What are carbonated, alkaline, chalybeate, saline, and sulphur waters?

Waters having special ingredients which meet therapeutic indications. Those containing an excess of carbon dioxide are termed carbonated, others holding in solution the carbonates of the alkalies are called alkaline; saline waters those containing neutral salts in serviceable quantities; while the waters containing hydrogen sulphide or alkaline sulphides in solution are sulphur waters, and when iron is contained in them they are called chalybeate.

What is hydrogen peroxide? Its properties?

A colorless syrupy liquid, sp. gr. 1.45, formula H_2O_2, m. w. 34. It is a powerful bleacher and deodorizer, unstable when concentrated, less so when in dilute solutions (commercial 1–10). In decomposition it gives off nascent oxygen.

How is it prepared?

By decomposing barium peroxide with sulphuric acid or carbonic acid.

$$BaO_2 + H_2SO_4 = BaSO_4 + H_2O_2.$$

Electronegative Monads—Halogens.

What elements belong to this group?

Chlorine, bromine, iodine, fluorine.

Why are they also called halogens?

Because they are *salt producers*, *i. e.*, they produce with the metals salt-like derivatives.

Chlorine.

What is chlorine?

A yellowish-green elementary gas of suffocating odor, symbol, Cl, a.w. 35.37, m.w. 70: 1 liter weighs 3.17 grams. Sp. gr. 2.46.

What are its physical properties?

It is coercible at 15° C. and 4 atmospheres pressure; freely soluble in water, 1 volume at 20° C. taking up two volumes Cl; this solution being known as chlorine water; this forms crystals of chlorine hydrate ($Cl_2 + 10\,H_2O$), below 0° C., but decomposes into its constituents at ordinary temperature.

Give its principal chemical properties.

It has a great affinity for almost all elements forming chlorides with them. This often takes place amidst heat and light phenomena, as when Dutch metal leaf or powdered antimony is thrown into the dry gas. It decomposes with water and other hydrogen compounds into HCl and O. It decolorizes indigo and litmus solutions, also other organic colors when moist, by liberating nascent O, and also destroys organic germs in this manner.

What is meant by nascent O and by nascent state?

Nascent O means O at the moment of liberation before it assumes its free or molecular state. The nascent state of bodies really implies their atomic or also unsaturated state.

Is chlorine combustible or a supporter of combustion, and what occurs when a burning candle is immersed in chlorine?

It is not combustible but a supporter of combustion; a burning candle will continue to burn in it, giving off dense volumes of carbon.

How is chlorine prepared?

By heating a mixture of manganese dioxide with hydrochloric acid or with the materials forming the latter, namely, chloride of sodium and sulphuric acid.

Explain the former process by equation and also the latter.

MnO_2	+	$4\,HCl$	=	$MnCl_2$	+	$2Cl$	+	$2\,H_2O$
Manganese dioxide.		Hydrochloric acid.		Manganous chloride.		Chlorine.		Water.

Manganous chloride being formed which dissolves in the water. The other process depends upon the formation of hydrochloric acid and the decomposition of this by the manganese dioxide:

$2NaCl$	+	H_2SO_4	=	Na_2SO_4	+	$2HCl$.
Sodium chloride.		Sulphuric acid.		Sodium sulphate.		Hydrochloric acid.

Again: MnO_2	+	H_2SO_4	+	$2HCl$	=	$MnSO_4$	+	$2H_2O$	+	Cl_2.
Manganese dioxide.		Sulphuric acid.		Hydrochloric acid.		Manganous sulphate.		Water.		Chlorine.

What is the compound of chlorine and hydrogen?

Hydrogen chloride or hydrochloric acid, formula HCl, m. w. 36.37, a colorless gas, sp. gr. 1.26, of pungent odor, fuming in the air, irritates the air passages, very soluble in water, 1 volume dissolving 450 volumes at 15° C., the solution being known as hydrochloric or muriatic acid.

What is the acidum hydrochloricum U. S. and what acidum hydrochloricum dilutum U. S.?

The former is a colorless solution of pure HCl in water, sp. gr. 1.16; the latter is the further dilution of the stronger to the sp. gr. 1.049, containing 10 per cent. HCl.

What are the tests for the recognition of HCl?

Its vapors redden moist litmus paper, and give dense white vapors with ammonia.

What are further tests for HCl and soluble chlorides?

They give white, curdy precipitates with silver nitrate, which are soluble in ammonium hydrate.

Does free hydrochloric acid exist in the body, and where?

Yes; in the gastric juice.

What is the character of the stain on textiles by hydrochloric acid?

Dark textiles are generally stained red by it; the stain is evanescent and readily removed by ammonium hydrate.

State in brief its poisonous action.

Its action on the tissues is that of a corrosive, producing extreme laryngeal irritation, even œdema and consequent asphyxia, black eschars on tongue and pharynx, corrosion and possibly perforation of œsophagus and stomach, and even in absence of this, it may cause subsequently inanition from destruction of mucous surfaces or stricture of the œsophagus.

What are the antidotes for poisoning by HCl?

Alkaline carbonates in dilute solutions, alkaline earths, magnesia, and soap-suds.

What class of poisons does it belong to, which are the principal ones of this class, and what is the mode of their toxic action?

It belongs to the corrosive acids, the principal ones of which are sulphuric, nitric, and hydrochloric acid; they act by the destruction of the tissue they come in contact with, but not by absorption.

How is the strength of acids quantitatively determined, and upon what is this process based?

By *acidimetry*, wherein the acids are neutralized by alkaline solutions of known strength, termed volumetric solutions.

How are the volumetric solutions of KOH and $NaOH$ prepared?

By making solutions of these alkalies and standardizing them with a normal solution of oxalic acid, which contains as many grams of the latter in a liter of distilled water as one-half of its molecular weight. The alkaline solution must be made of such strength as to neutralize exactly the oxalic acid solution volume for volume.

How is the process of acidimetry performed?

A certain amount, say 10 c.c., of the solution to be tested is placed in a beaker glass, diluted, and to it are added a few drops of red litmus solution as an indicator; then the volumetric alkaline solution is dropped into the former until the change of color of the litmus to a violet indicates the neutralization. The result of the neutralization is then computed either by stoichiometric proportion or by reference to already computed tables. When the acidity of mixed acids is wanted this is expressed in comparative amounts of oxalic acid.

Which are the oxygen compounds of chlorine?

Cl_2O hypochlorous oxide or hypochlorous anhydride.
Cl_2O_3 chlorous oxide or chlorous anhydride.
Cl_2O_5 chloric oxide or chloric anhydride.
Cl_2O_7 perchloric oxide or perchloric anhydride.

What do they form with water respectively?

$Cl_2O + H_2O = 2HClO$ hypochlorous acid.
$Cl_2O_3 + H_2O = 2HClO_2$ chlorous acid.
$Cl_2O_5 + H_2O = 2HClO_3$ chloric acid.
$Cl_2O_7 + H_2O = 2HClO_4$ perchloric acid.

Are these compounds stable? In what form are they principally found, and what are those of medical interest?

They are unstable, and are generally found as salts of the acids, of which the hypochlorite of calcium $Ca(ClO)_2$, hypochlorite of sodium $NaClO$, and the potassium chlorate $KClO_3$, are of importance in medicine.

In what substance is calcium hypochlorite contained, and with what other substance? How prepared?

In calx chlorata, chlorinated lime, also called chloride of lime, commonly known as bleaching powder, which consists of a mixture of calcium chloride $CaCl_2$ and calcium hypochlorite $Ca(ClO)_2$. It is prepared by saturating slaked lime with chlorine gas.

What preparation depends upon the presence of sodium hypochlorite for its efficacy?

The liquor sodæ chloratæ or chlorinatæ, otherwise known as Labarraque's solution. It is prepared by decomposing a saturated solution of chlorinated lime with a solution of sodium carbonate, the latter being in excess. It is a powerful disinfectant, as, in its decomposition, it gives rise not alone to chlorine, but to nascent O also.

Bromine.

What is bromine? Its physical properties?

An elementary liquid, of dark reddish-brown color, and disagreeable odor. Symbol Br, a. w. 80; sp. gr. 3.18 at 0° C.; it crystallizes at —7.3° C; boils at 63°, giving rise to yellowish-brown vapors; at a lower temperature the vapors are dark-brown; one part of it at 15° C. dissolves in 39 Aq. It is soluble in alcohol, but more so in ether, chloroform, and carbon bisulphide.

What are its chemical properties?

Very much like those of chlorine, but less active, bleaching like it, but in a less degree. It colors starch yellow.

When and how does bromine occur in nature?

In sea-water and in saline springs, termed bitterns, as bromides.

How is bromine prepared?

Like chlorine, by warming a mixture of manganese dioxide, and sodium bromide with sulphuric acid.

$$MnO_2 + 2NaBr + 2H_2SO_4 = MnSO_4 + Na_2SO_4 + Br_2 + 2H_2O.$$

What is the hydrogen compound of bromine?

Hydrogen bromide or hydrobromic acid HBr.

How is HBr made? Its properties?

By decomposing Br in H_2O with hydrogen sulphide, as follows: $Br_2 + H_2O + H_2S = H_2O + S + 2HBr$; also by decomposition of a bromide with sulphuric acid. It is a colorless gas fuming on contact with the air.

What is strong and what diluted hydrobromic acid?

The strong is a concentrated solution of gaseous HBr in water, which when diluted to contain 10 per cent. HBr, sp. gr. 1.044, constitutes acidum hydrobromicum dilutum of the Pharmacopœia.

Which of the oxyacids of Br are used, and in what form?

The hypobromous acid HBrO, as sodium hypobromite in the Knop's solution for determining urea, *q. v.*

Iodine.

What is iodine? Its physical properties?

A crystalline, elementary body of metallic lustre. Symbol I, a. w. 127; sp. gr. 4.95; fusing at 113° C. to a liquid, and boiling at 200° C., giving off dark-violet vapors. It is slightly soluble in water, more readily in alcohol; in this form, when of officinal strength, it is the *tinctura iodi;* it is readily soluble in ether, chloroform, and carbon disulphide, in the last two with violet color; potassium iodide favors its solution in water.

Give its chemical properties.

These are similar to chlorine and bromine, but weaker; it imparts a blue color to starch.

Where does iodine occur in nature, and how is it prepared?

It occurs in mineral springs and sea-water. Seaweed contains it, and when burned is known as kelp, from which it is manufactured by a similar process to that employed for chlorine and bromine; the magnesium iodide and sodium iodide being mixed with manganese dioxide and warmed with H_2SO_4.

What is the hydrogen compound of iodine?

Hydrogen iodide or hydriodic acid HI, a colorless gas, which is very soluble in water; prepared similarly as hydrobromic acid, by treating iodine in water with hydrogen sulphide. It enters into the syrupus acidi hydriodici of the Pharmacopœia.

Fluorine.

What is fluorine, and its properties?

Probably an elementary gas. Symbol Fl, a. w. 19. Of such strong affinity for almost all substances, that it cannot be obtained free.

What is its principal compound, and from what is this obtained?

Its principal compound is hydrogen fluoride HFl, or hydrofluoric acid ; it is obtained by the action of warm sulphuric acid on fluor-spar, the calcium fluoride ; $CaFl_2 + H_2SO_4 = CaSO_4 + 2HFl$.

What are the properties of hydrofluoric acid? Is fluorine found in the human economy, and where?

The aqueous solution of the gaseous hydrofluoric acid is a colorless liquid, very corrosive, and attacking the tissues severely. It also attacks glass, and is used for etching it. Fluorine, as fluoride of calcium, is found in the enamel of teeth and in the bones.

Electronegative Dyads.

Which elements compose this group?

Sulphur, selenium, and tellurium (properly oxygen also).

Sulphur.

What is sulphur?

A solid elementary body, capable of existing in several allotropic conditions. Symbol $S^{II\ IV\ VI}$, a. w. 32.

State the different systems of crystallization, and their characteristics.

1. The regular or tesseral system, the crystals of which have three axes of equal length, intersecting each other at right angles.
2. The quadratic or tetragonal system, the crystals of which have one longer and two shorter axes ; the latter of equal length and all intersect each other at right angles.
3. The hexagonal or rhombohedral system ; the crystals of this system have four axes, three of equal length, which intersect each other in one plane at angles of 60° ; the fourth, a longer axis, intersects their plane at 90°.
4. The rhombic system, the crystals of which are all of unequal length, and intersect each other at 90°.
5. The monoclinic system ; its crystals have three unequal axes ; two of which intersect at 90° ; the third intersects one at 90°, and the other obliquely.

6. The triclinic system comprises the crystals which have three unequal axes, all obliquely inclined to each other.

What is the physical structure of the different allotropic conditions of sulphur, and how is their occurrence accounted for?

1st, ordinary octahedral or rhombic sulphur, sp. gr. 2.05; 2d, prismatic or monoclinic sulphur, sp. gr. 1.98; 3d, soft, plastic sulphur, sp. gr. 1.95. These different modifications may be accounted for by the presence of varying numbers of atoms in their molecules.

What is the effect of different degrees of heat on sulphur?

It melts at 115° C. as a pale yellow liquid; between 200° and 250° C. it becomes viscid; above that it becomes fluid again and boils at 440° C.

In what different forms does sulphur come in commerce?

Roll sulphur, sublimed sulphur, which, when washed free from adhering acids, is termed sulphur lotum; precipitated or lac sulphuris.

Where and how does sulphur occur in nature?

It is found free in volcanic regions; also as compounds with many metals as well as in organic substances.

How does sulphur behave chemically?

Similar to oxygen, forming binary compounds with most of the metals, burning in the air with bluish flame to form sulphur dioxide SO_2, and it may also exhibit linking powers like oxygen.

What is the hydrogen compound of sulphur? Its properties?

Hydrogen sulphide, also termed sulphuretted hydrogen, H_2S; a gaseous colorless body of the odor of rotten eggs, sp. gr. 1.177, and coercible; soluble 3–4 volumes in 1 of water. It is combustible, weakly acid, and poisonous.

How is H_2S prepared?

By the action of H_2SO_4 on ferrous sulphide FeS.

$$FeS + H_2SO_4 = FeSO_4 + H_2S.$$

How is ferrous sulphide made?

By fusing together iron filings and sulphur.

What does H_2S form with metals?

Metallic sulphides.

Does H_2S occur in the body? Where and how does it form?

It occurs in the body from decomposition of albuminous food in the flatus; from the tartar of the teeth and from decay of food between them; it gives rise to the blue line on the gums in lead poisoning.

How does H_2S act as a poison?

By combining with and reducing the hæmoglobin.

Where does it occur, and what symptoms does it give rise to when inhaled for some time?

In sewer gas, the inhalation of which for some time gives rise to giddiness, headaches, and low fevers.

What are the antidotes for H_2S poisoning?

Stimulants, fresh air, and chlorine.

What are the tests for H_2S?

Its characteristic odor and moist lead acetate paper, by which 1 in 10,000 can be detected.

What are the principal oxygen compounds of sulphur?

Sulphur dioxide, sulphurous oxide So_2, and sulphur trioxide, sulphuric oxide So_3.

What is sulphur dioxide and its principal properties?

A colorless gas of pungent suffocating odor, SO_2, m. w. 64, sp. gr. 2.247; coercible at —15° C. or at ordinary temperature, and two atmospheres of pressure, crystallizing at —76° C.; 50 volumes soluble in 1 volume water; neither a supporter of combustion nor combustible.

What are its principal chemical properties?

It unites with H_2O to form sulphurous acid, H_2SO_3; is a reducing agent, *i. e.*, has great affinity for oxygen.

What is the sulphurous acid U. S.?

A solution of H_2SO_3 in water, of the characteristic odor of burning sulphur, sp. gr. 1.022–1.023, and of strongly acid reaction.

For what purposes is SO_2 employed, and how?

To put out fires, bleach, reduce oxygen compounds, and as a germicide. For disinfecting purposes sulphur is burned in a closed room; about 2 pounds are used for 1000 cubic feet of floor room.

How is SO_2 prepared?

By burning sulphur in oxygen or in atmospheric air, $S_2+O_4=2SO_2$, also by the action of H_2SO_4 either on copper or charcoal, sulphur dioxide being liberated, and in the latter process also CO_2.

$$2H_2SO_4+Cu=CuSO_4+SO_2+2H_2O,$$

$$\text{also, } 2H_2SO_4+C=CO_2+2SO_2+2H_2O.$$

What is sulphuric oxide or sulphur trioxide?

A white solid, crystallizing in silky needles SO_3, which unites with H_2O to form H_2SO_4; it has no acid properties.

What is sulphuric acid?

A dense colorless, inodorous, corrosive liquid H_2SO_4, m. w. 98, sp. gr. 1.84, containing not less than 96 per cent. H_2SO_4. The acidum sulphuricum dilutum U. S. contains 10 per cent. H_2SO_4, sp. gr. 1.067. The commercial H_2SO_4 is known as oil of vitriol.

State some of the principal properties of H_2SO_4.

It is a dibasic acid forming two salts with monad metals, which if H is present are termed acid, or if two metallic atoms normal salts. It has a great attraction for water, evolving heat when mixed with it; on this account it is used for drying gases and precipitates.

Give in brief the process for the manufacture of H_2SO_4.

This may be stated as taking place in four stages.

1. The formation of sulphur dioxide by burning sulphur or pyrites with access of air. $S+O_2=SO_2$.

2. Generating nitrogen tetroxide N_2O_4, which gives off oxygen to the SO_2 forming SO_3 and N_2O_2,

as follows: $2SO_2+N_2O_4=2SO_3+N_2O_2$.

3. The SO_3 is mixed with aqueous vapor resulting in the formation of H_2SO_4,

$$SO_3+H_2O=H_2SO_4.$$

While, 4th, the N_2O_2 is reoxidized by contact with the oxygen of the air,

$$N_2O_2+O_2=N_2O_4,$$

and can be used again as before, the whole of the process being conducted in leaden chambers; the resulting liquid is condensed to the proper specific gravity.

What class of poisons does H_2SO_4 belong to, and what are the symptoms caused by it?

It belongs to the corrosive mineral acids, causing white eschars on tongue, lips, and pharynx, possibly œdema of larynx and perforation of stomach, and, if not, the patient may die of inanition eventually.

What are the antidotes for poisoning by sulphuric acid?

Magnesia, alkaline carbonates, soap-suds, also eggs and milk.

What are the tests for sulphuric acid?

Red stains on dark textiles, disappearing on application of ammonium hydrate. H_2SO_4 and the soluble sulphates give dense white precipitates with barium chloride or nitrate; when concentrated down H_2SO_4 will char the carbohydrates. Paper moistened with a diluted H_2SO_4, and the water evaporated by gentle heat will char. Concentrated H_2SO_4 heated with copper slips will liberate vapors of sulphur dioxide.

What is hyposulphurous acid, and what is sodium hyposulphite?

Hyposulphurous acid H_2SO_2, an unstable compound; the so-called sodium hyposulphite $Na_2S_2O_3$ is really not a hyposulphite but a thiosulphate.

What is Nordhausen or fuming sulphuric acid?

A thick, oily, fuming liquid, sp. gr. 1.85-1.9, sometimes called disulphuric acid, because its formula may be obtained from two molecules of H_2SO_4 by the subtraction of H_2O; $2H_2SO_4—H_2O=H_2S_2O_7$. It splits up by heat into H_2SO_4 and SO_3, so that it may be considered a solution of SO_3 in H_2SO_4. It dissolves indigo.

Electronegative Triads or Nitrogen Group.

Which elements belong to this group?

Nitrogen, phosphorus, arsenic, antimony, bismuth.

Nitrogen.

What is nitrogen?

An elementary gas, symbol $N^{I\ III\ V}$, a. w. 14, sp. gr. 0.971; one liter weighs 1.25 grams.

What is it also called, and where does it occur free?

It is also called azote, and occurs free in the atmosphere, of which it constitutes about four-fifths.

Give the properties of N.

It is colorless, odorless, tasteless; coercible only at —130° C. and 280 atmospheres; it is neither combustible nor a supporter of combustion; it combines directly with very few substances; it extinguishes flames and life when immersed in it.

How can nitrogen be prepared?

By isolating it from the air by burning phosphorus in a closed vessel; also by decomposing ammonium nitrite by heat as follows:—

$$\underset{\text{Ammonium nitrite.}}{NH_4NO_2} = \underset{\text{Nitrogen.}}{N_2} + \underset{\text{Water.}}{2H_2O.}$$

What is the atmosphere?

A gaseous envelope surrounding the earth, composed of a mechanical mixture of oxygen by volume 20.8 and nitrogen 79.2 in 100 volumes. It contains, besides a little CO_2, some aqueous vapor, also traces of NH_3, CH_4, H_2S, SO_2; the proportions of N and O are very constant.

State the probable height of the atmosphere and the pressure exerted by it on the square inch.

The height of the atmosphere has been variously computed from 50–150 miles. It exerts a pressure of 15 pounds to the square inch.

How can atmospheric pressure be demonstrated?

By filling a glass tube over 30 inches in length with mercury and reversing it while immersed in a vessel of mercury; the column of mercury in the tube will at once fall to about 30 inches or 760 millimetres; this column is counterpoised by the atmosphere, and there will be a vacuum above it.

What instruments are based upon this, and how are they constructed?

Barometers for measuring atmospheric pressure. They are glass tubes closed at the top and ending in a cistern or syphon of mercury. They have attached to the tube a scale for measuring the height of the column of mercury.

State the cause of variable atmospheric pressure.

Storms, changes in the meteorological condition, and increased or decreased altitudes.

How does atmospheric pressure affect the volume of gases?

Greater pressure diminishes their volume and diminished pressure increases it.

What other factors influence the volume of gases, and how?

Heat increases their volume, cold diminishes it.

What has to be done to compare volumes of gases, and how is this done?

They have to be reduced to a common standard at 0° C. and 760 mm. pressure. This can be accomplished by the following formula:—

$$V = \frac{v.\ p.}{760\,(1+0.00366\,t.)}$$

[illegible] 0° C and 760 mm. pressure [illegible] observed pressure; t [illegible] .00366 is the coefficient for the [illegible]

What is the compound of nitrogen and hydrogen?

Ammonia, [illegible] one liter weighs 0.762 grams.

Give the principal properties of ammonia.

It is a colorless gas of pungent odor; sp. gr. [illegible]; coercible at [illegible] pressure at —40° [illegible] 760 mm. 1050 volumes NH_3 [illegible] supporter of combustion. It [illegible] nitrogen compounds. [illegible]

How is NH_3 obtained and how prepared?

It is obtained [illegible] liquor of gasworks, and [illegible] lime (CaO) on ammonium chloride (NH_4Cl).

$$2NH_4Cl + CaO = CaCl_2 + H_2O + 2NH_3$$

Give the names and formulæ of the oxygen compounds of nitrogen.

Nitrogen monoxide, N_2O, a colorless gas.

Nitrogen dioxide, N_2O_2, a colorless gas turning red with O or atmospheric air.

Nitrogen trioxide, nitrous anhydride, N_2O_3, a dark blue liquid.

Nitrogen tetroxide, N_2O_4, a yellowish-brown liquid or gas.

Nitrogen pentoxide, nitric anhydride, N_2O_5, a white crystalline solid.

What is nitrogen monoxide?

It is a colorless gas of sweetish taste and slight odor, sometimes termed nitrous oxide, also laughing gas, N_2O, m. w. 44; one liter weighs 1.97 grams; sp. gr. 1.527; coercible with 30 atmospheres pressure at 0° C. It is a supporter of combustion, inflaming glowing embers immersed in it as in oxygen.

How is N_2O produced?

By the decomposition of ammonium nitrate by heat.

$$NH_4NO_3=N_2O+2H_2O.$$

What is its physiological effect, and for what purposes used?

It produces first exhilaration, then anæsthesia and asphyxia. It is used as an anæsthetic for short operations, for which it is regarded as quite safe.

What is nitrogen dioxide?

A colorless gas N_2O_2, m. w. 60; one liter weighs 1.34 grams; sometimes called nitric oxide, sp. gr. 1.038, coercible, slightly soluble in water, forms with O or atmospheric air brown vapors of nitrogen tetroxide N_2O_4.

How is N_2O_2 prepared, and for what used?

By the reduction of nitric acid by metals, such as copper, $Cu_3+8HNO_3=3Cu(NO_3)_2+4H_2O+N_2O_2$; it may be employed to detect oxygen in gases.

What is nitrogen trioxide?

A dark blue liquid boiling at 0° C., N_2O_3, m. w. 76; it forms with water nitrous acid, $N_2O_3+H_2O=2HNO_2$, which forms nitrites with bases.

Describe nitrogen tetroxide and its use.

A yellowish-brown liquid or brown vapor at ordinary temperature; N_2O_4 resulting when N_2O_2 is exposed to the air. It is an oxidizing agent, used in converting H_2SO_3 into H_2SO_4.

State what results when nitrogen pentoxide unites with water, and give character of product.

Nitrogen pentoxide forms with water nitric acid, $N_2O_5+H_2O=2HNO_3$, a colorless, fuming, corrosive acid liquid, m. w. 63, sp. gr. 1.52.

How is nitric acid prepared?

By the action of sulphuric acid on a nitrate.

$$\underset{\substack{\text{Sodium}\\\text{nitrate.}}}{NaNO_3} + \underset{\substack{\text{Sulphuric}\\\text{acid.}}}{H_2SO_4} = \underset{\substack{\text{Nitric}\\\text{acid.}}}{HNO_3} + \underset{\substack{\text{Acid sodium}\\\text{sulphate.}}}{NaHSO_4}$$

What are the chemical properties of HNO_3?

It is a monobasic acid of great oxidizing power, coloring organic nitrogen compounds yellow, and converting others, such as glycerin, cotton, etc., into explosives of great force.

What is fuming nitric acid? What the acidum nitricum U. S., and the acid. nitric. dil. U. S.?

Fuming nitric acid is a nitric acid containing nitrogen dioxide in solution. Acid. nitric. U. S. a colorless nitric acid, sp. gr. 1.42, containing 69.4 per cent. HNO_3. Acid. nitric. dilut. has a sp. gr. 1.039, and contains 10 per cent. HNO_3.

What is the effect of HNO_3 as a poison?

The same as the other corrosive mineral acids, with the only difference that the eschars are yellow.

Give the tests for nitric acid and for nitrates.

Nitric acid gives yellowish-red stains on dark textiles, not removable by ammonium hydrate; it colors blue litmus red, darkens ferrous sulphate in presence of sulphuric acid, bleaches indigo solution, gives rise to red vapors with copper slips, and gives a red color on addition of brucine. The nitrates are recognized by the same tests if the HNO_3 is first liberated by H_2SO_4.

What is nitro-hydrochloric acid?

A mixture of 3 parts of HNO_3 and 5 of HCl, also called aqua regia, as it dissolves gold and platinum, which neither alone effects. This is due to free chlorine and chlorine derivatives (nitroxyl chloride NO_2Cl and nitrosyl chloride NOCl).

Phosphorus.

What is phosphorus?

A waxlike, colorless, or slightly yellow, semi-transparent elementary solid, luminous in the dark. Symbol $P^{I\ III\ V}$, a. w. 31, m. w. 124, vapor density 62, sp. gr. 1.83, melts at 44° C. to a colorless liquid, boils at 290° C. It occurs in two allotropic states.

How is the molecular weight of bodies obtained?

By multiplying their vapor density by two.

What are some of the principal physical properties of phosphorus?

It is soft and tough at ordinary temperature, insoluble in water, soluble in ether and alcohol, very soluble in carbon disulphide, from which it crystallizes in rhombic dodecahedra.

Describe what two principal allotropic modifications of phosphorus there are, and what properties has the second.

The one is yellow and the other is dark-red ; the latter is called amorphous ; the red is insoluble in carbon disulphide, is not luminous, is not poisonous, and does not melt.

How is red phosphorus prepared from the yellow?

By heating the yellow in an atmosphere of CO_2 to 300° C.

State the chemical properties of phosphorus.

It has a great affinity for O, combining with it at a comparatively low temperature, and for that reason has to be kept under water. It also combines with H and Cl, Br and I.

Where and how does phosphorus occur?

It is not found free in nature, but as phosphates. Its principal source is the calcium phosphate of bones.

What is one of the technical uses for phosphorus?

In the manufacture of friction matches, for which the red variety is preferable as less injurious to the operators. It is also used in rat poisons.

What is the local action of phosphorus?

When handled carelessly it ignites, causing severe burns and sloughs, not infrequently accompanied by systemic intoxication.

What are the results of inhaling its fumes for some time, as in match factories?

Chronic poisoning, resulting frequently in maxillary necrosis.

State the symptoms of acute poisoning by phosphorus.

It is an insidious poison, killing sometimes soon after ingestion, but frequently only for some time after with symptoms of acute, yellow atrophy of liver, jaundice, suppression of urine, delirium, uræmia, and coma.

What is the treatment for and what is the antidote to poisoning by phosphorus?

Stomach pump, cupric sulphate as emetic, which is antidotal as well, rendering the phosphorus non-assimilable as copper phosphide, also old spirits of turpentine.

How can the lucifer disease in match factories be prevented?

By good ventilation, and having oil of turpentine placed openly about the work-rooms, and worn in cloths or sponges around the necks of operators, but principally by the employment of the red variety only.

What is a good test for phosphorus?

By boiling the substance suspected to contain it in acidulated water, and allowing the vapors to strike a paper containing silver nitrate, which is colored dark by the formation of silver phosphide.

Explain the principle of Mitscherlich's test for phosphorus.

It is based upon the distillation of the substance suspected to contain phosphorus from acidulated water, when, upon striking the cool surface of the condenser, it will give rise to luminosity at that point if viewed in the dark. Alcohol, ether, oil of turpentine, and other essential oils interfere with this test.

In examining vomited matter or a stomach suspected to contain phosphorus, what should be done?

It should be inspected in the dark for luminosity, and also be examined for its characteristic odor.

What is phosphine?

A hydrogen compound of phosphorus, termed hydrogen phosphide PH_3, m. w. 34. It is a colorless gas, with a garlicky odor. It ignites at about 100° C., is poisonous, and is sometimes liberated in marshes, when it is known as the ignis fatuus or Will-o'-the-wisp.

Give the oxygen compounds of phosphorus.

Phosphorus trioxide P_2O_3 and phosphorus pentoxide P_2O_5.

Which are the direct acids of phosphorus?

Hypophosphorous acid H_3PO_2, the oxide of which has not been isolated. Phosphorous acid derived from $P_2O_3 + 3H_2O = 2H_3PO_3$. Phosphorous pentoxide yields with water orthophosphoric acid H_3PO_4, as follows: $P_2O_5 + 3H_2O = 2H_3PO_4$.

What are the other phosphoric acids, and how derived?

By the abstraction of one molecule of water from respectively one or two molecules of H_3PO_4, the meta- and pyrophosphoric acids are formed as follows:—

$H_3PO_4 - H_2O = HPO_3$ or metaphosphoric acid.

$2H_3PO_4 - H_2O = H_4P_2O_7$ or pyrophosphoric acid.

State the salts respectively formed by the different phosphoric acids.

Hypophosphorous acid forms hypophosphites, phosphorous acid phosphites, orthophosphoric acid orthophosphates, metaphosphoric acid metaphosphates, and pyrophosphoric acid pyrophosphates.

What salts are formed by the orthophosphoric or tribasic phosphoric acid?

Three different kinds of salts, according to the number of H atoms displaced. Thus the mono-sodium or acid sodium phosphate NaH_2PO_4 as found in the urine; di-sodium or neutral sodium phosphate Na_2HPO_4 as found in the blood; also the hydrocalcium phosphate $Ca\ (H_2PO_4)_2$, and the normal calcium phosphate $Ca_3\ (Po_4)_2$ of the bones. Besides these, double salts may be formed by a univalent and a divalent atom together displacing the three H as in ammonium-magnesium phosphate $NH_4'Mg''PO_4$.

Which is the acidum phosphoricum of the U. S. Pharmacopœia, and what the test for it?

The orthophosphoric acid H_3PO_4, recognized by giving a yellow precipitate with silver nitrate when neutralized with ammonium hydrate, and by giving a white precipitate with the magnesium mixture. These tests apply equally to its salts.

Arsenic.

What is arsenic?

A steel-gray crystalline, elementary solid, of metallic lustre. Symbol $As^{III\ V}$, a. w. 75; sp. gr. 5.7, m. w. 300 (a second amorphous variety of black color, has a sp. gr. of 4.71); volatilizes at 180° C. without fusing, giving rise to yellowish-brown fumes of garlicky odor. It gradually oxidizes in the air, and burns at red heat with blue flame to form arsenious oxide.

How is arsenic found in nature?

Sometimes in its free state, but generally as a compound of other elements, such as sulphur or oxygen (As_2O_3) and the metals Fe and Co. It is separated from its oxide by heating with charcoal $As_2O_3 + 3C = 2As + 3CO$.

What is the technical use of arsenic?

In fireworks, the manufacture of shot, and as fly-powder, under the name of cobalt or fly-stone.

Describe the hydrogen compound of arsenic.

Hydrogen arsenide or arsine, also called arseniuretted hydrogen, a colorless gas of garlicky odor AsH_3, m. w. 78, sp. gr. 2.7; it is very poisonous.

What are the chemical properties of AsH_3?

It burns in the air with a bluish flame, to arsenious oxide As_2O_3. If its combustion is interfered with by introducing into its flame a cold surface of porcelain, it deposits thereon a brownish-black stain of elementary arsenic. If heated to redness in a glass tube conducting it, it deposits a mirror-like ring of elementary arsenic beyond the flame. It decomposes solutions of silver nitrate into metallic silver, forming arsenious acid.

How is hydrogen arsenide formed and prepared?

By the action of nascent hydrogen on arsenical compounds, also by the action of moist air and organic compounds on arsenical pigments. It is principally prepared by generating hydrogen in the presence of arsenious oxide as follows:—

$$6Zn + 6H_2SO_4 + As_2O_3 = 6ZnSO_4 + 3H_2O + 2AsH_3.$$

What compounds does arsenic form with oxygen?

Arsenic trioxide or arsenious oxide As_2O_3, and arsenic pentoxide or arsenic oxide As_2O_5.

In what forms does arsenic trioxide occur?

It occurs in two varieties, the vitreous or amorphous as transparent glassy masses, sp. gr. 3.78, which gradually change to the non-transparent or porcelainous variety of crystalline structure, sp. gr. 3.69. The commercial variety comes in powder form and is called white arsenic.

State the properties of As_2O_3.

It volatilizes at 218° C., is white or colorless, odorless, is only slightly soluble in cold water, about 1 to 2 parts per 1000, more readily soluble in boiling water, and after boiling for one hour 60–80 parts dissolve in 1000. (Aqua Tofani.)

What is the action of HNO_3 on As_2O_3?

It gives up O to the As_2O_3 and forms As_2O_5.

What do the oxides of arsenic form with water?

Arsenic trioxide forms with water arsenious acid, $As_2O_3 + 3H_2O = 2H_3AsO_3$. Arsenic pentoxide forms arsenic acid. $As_2O_5 + 3H_2O = 2H_3AsO_4$, both giving acid reactions.

Name the respective salts of arsenious and arsenic acid.

Arsenites and arseniates.

Which are the principal compounds of arsenic with the halogens?

Arsenic trichloride $AsCl_3$, a colorless oily liquid. Arsenic tribromide $AsBr_3$, a white crystalline substance. Arsenic triiodide AsI_3, red crystals.

What are the sulphur compounds of arsenic?

Arsenic trisulphide As_2S_3 when As_2O_3 is precipitated by H_2S; it also occurs in nature as *auripigment* or *orpiment* or king's yellow, and is used as a yellow pigment, also as a depilatory. There is also an arsenic pentasulphide As_2S_5, and an arsenic disulphide As_2S_2; the latter exists in nature, and under the name of *realgar* is used as a red pigment.

Name the Pharmacopœial preparations of arsenic and their strength.

Liquor potassii arsenitis, Fowler's solution, 1As_2O_3, and 1$KHCO_3$ in 100 water with compound spirit of lavender.

Liquor acidi arseniosi, solution of arsenic chloride, containing 1 part As_2O_3 and 2 parts HCl in 100 water.

Liquor arsenici et hydrargyri iodidi, Donovan's solution, containing 1 part AsI_3 and 1HgI_2 in 100 water.

Liquor sodii arseniatis, solution of sodium arseniate, Pearson's solution, 1 part anhydrous sodium arseniate in 100 water.

What is Scheele's green, and what Paris green?

Compounds of arsenious acid and copper, frequently used with homicidal intent, and employed to destroy insects.

Do wall papers contain arsenic, and in what quantity?

Many contain arsenic in quantities from 1 to 50 grains to the square yard. This is not confined to low priced paper or those of green color alone.

Is arsenic found in textiles, etc., and how may it prove injurious in this way?

It is found in various textiles, prints, cretonnes, tarlatans, etc., and may give rise to poisonous symptoms by direct absorption as well as by inhalation of AsH_3 produced from the reduction of the As_2O_3 therein.

In what manner does arsenic prove poisonous?

Elementary arsenic is probably not poisonous as such, but by oxidation it becomes so. As fly-stone or fly-paste it becomes poisonous by oxidation to As_2O_3.

How is AsH_3 as a poison?

It is the most poisonous of all As compounds, on account of its rapid absorption by the lungs.

Which is the most common poisonous compound of As?

As_2O_3, contained in the ratbanes of the market; its smallest poisonous dose is two grains; but recovery has been known to take place after ingestion of two ounces; chances appear better for recovery after large doses than small ones, as they are more promptly ejected. Fowler's solution taken in overdoses frequently proves a source of poisoning; children appear less susceptible than adults.

What is the toxic action of arsenic compounds?

They are irritants but not corrosives; ulceration results from irritation and inflammation indirectly, therefore the stomach-pump may be used in the earlier stages but not later on. Inflammation may also be found in the intestines, peritoneum, and bladder, but principally in the duodenum, œsophagus, pharynx, and the mouth may also be inflamed from vomiting.

What are the preserving powers of arsenical compounds?

Cadavers are preserved by them, and thus marked preservation of an exhumed body would direct suspicion to arsenical poisoning.

Give the symptoms of arsenical poisoning.

They come on in from a half hour to ten hours; if early, chances for recovery are more favorable. Symptoms: austere metallic taste, fetid breath, constriction of pharynx and œsophagus, sinking sensation with great præcordial pains, retching and vomiting, intense thirst, but drinks are not tolerated no matter how bland; darting, shooting pains in colon, colitis, dark bloody stools, small thready pulse, cold skin, pinched nose, collapse, eruption of skin may break out in a few days, sensation benumbed, paralysis, tetanic spasms, delirium, prostration, and death.

Are all cases alike?

Not always; patient may die, as in cholera morbus or in Asiatic cholera, with suppression of urine and without gastric irritation, and the general symptoms may vary greatly.

What are the symptoms of slow arsenical poisoning?

Nausea, occasional vomiting, colitis, fever, debility, conjunctivitis, œdematous eyelids, ptyalism, alopecia, and brown pigmentary spots on skin.

What is the treatment for arsenical poisoning?

Evacuate the stomach by favoring emesis with warm water or warm milk or even zinc sulphate; give demulcents such as eggs and milk, and then give the chemical antidote, ferric hydrate in tablespoonfuls every 5-10 minutes, or in place of it dialyzed iron, which, however, is not so reliable.

How is ferric hydrate prepared? What its other name, and what its action as an antidote?

Ferric hydrate or hydrated oxide of iron can be prepared in different ways. It may be prepared by completely precipitating the solution of a ferric salt with ammonium hydrate and washing the resulting precipitate. A better preparation is the ferri oxidum hydratum cum magnesia, resulting by precipitating tinct. ferri chloridi f ʒiij with magnesia calcinata ℥ij. The mixture of these diluted with water should be exhibited freely. In absence of magnesia a solution containing one ounce of sodium carbonate may be substituted for it. When magnesia is used the reaction is as follows: $Fe_2Cl_6+3MgO+3H_2O=Fe_2(OH)_6+3MgCl_2$. The action of the antidote on arsenic trioxide may be demonstrated as follows: $2Fe_2(OH)_6+As_2O_3=Fe_32AsO_4+5H_2O+Fe(OH)_2$, *i. e.*, the arsenic trioxide will be converted into an inert ferrous arseniate.

Describe the test for arsenic when found in substance.

Place the particles found in a small reduction tube and heat, when it will be sublimed in the cooler portion of the tube as octahedral crystals. If the particles are covered with flux (a mixture of equal parts of dry sodium carbonate, and potassium cyanide), or with charcoal, the As_2O_3 will be reduced, and an arsenical mirror will form in the cooler portion of the tube. To confirm the character of the mirror, heat the mirror with access of air, when it will sublime in the cooler portion of the tube as a white ring, which, under the microscope, will be found composed of the octahedral crystals of As_2O_3.

What is necessary in testing for arsenic?

The test has to be confirmed in as many ways as possible.

How are solutions suspected to contain arsenic to be tested?

Acidulate them with a few drops of HCl, and treat with H_2S. If arsenic is present, a lemon-yellow precipitate will be thrown down; this is not soluble in cold HCl, and should be further tested after filtration and drying by reducing it with flux, and producing the arsenical mirror and the white ring of octahedral crystals.

What is Fleitmann's test for arsenic?

This depends on the fact that zinc or aluminium produces H with KOH or NaOH; the former at the boiling point, and the latter at ordinary temperature. If, after generating the H, the purity of the materials is tested by placing a piece of filtering paper moistened with $AgNO_3$ over the test-tube containing them, and this is not discolored by it, a few drops of the suspected liquid are added, when, if arsenic is present, the paper containing the $AgNO_3$ will present a dark stain; the presence of H_2S or sulphides should, however, first be excluded by testing the liquids with a solution of a lead salt. This test, while convenient as a preliminary test, is not conclusive evidence. It does not give any reaction with antimonials.

Describe some other tests for arsenic in solution.

Ammonio-sulphate of copper will give a bright-green precipitate with arsenical solutions, and ammonio-nitrate of silver a yellow precipitate. Neither of these precipitates is conclusive, and should be reduced with flux to give the mirror and subsequent white ring of octahedral crystals.

What is Reinsch's test for arsenic? Describe it.

The test by which arsenical compounds are reduced with metallic copper. To that purpose the purity of the copper and HCl should first be tested by boiling the copper slip or gauze in diluted HCl. If, after boiling, the copper does not tarnish, add some of the suspected liquid and boil again. If arsenic is present, the copper will be coated with elementary arsenic. This can be demonstrated by drying and rolling up the copper slip, and heating it in an open glass tube. If it is As, there will appear in the cooler portion of the tube the characteristic white ring of octahedral crystals of As_2O_3.

What other substances may deposit on the copper in this test?

Sb and Hg may also deposit on the copper in Reinsch's test, but they will give respectively amorphous or metallic globular sublimates.

How can Reinsch's test be made quantitatively?

By gradually inserting into the boiling acid mixture previously weighed pieces of copper until they are no longer coated; they are then dried and weighed; the increase in weight giving the amount of As in the quantity of liquid employed.

What are the advantages and disadvantages of Reinsch's test?

The advantages are that it can be made in the presence of organic matter; that it is very delicate, and can be made quantitative as well. Its disadvantages are that it is not available for arsenic acid or arseniates without previous reduction.

Describe Marsh's test for arsenic.

This depends upon generating H from pure zinc with pure H_2SO_4 from a suitable apparatus; the purity of the materials and apparatus being tested by allowing the hydrogen to burn for some time, and testing with a cool porcelain surface inserted into the flame. If no stain is thus produced, introduce some of the suspected liquid through the funnel tube, and again test the flame with the porcelain; if a stain results, arsenic may be present, the flame in this case will be blue, and if the conducting tube is heated to redness in its course, a mirror will form in the tube beyond the flame.

What are the advantages and disadvantages of Marsh's test?

Its advantages are that arsenious acid, arsenites, arsenic acid, and arseniates can be detected by it; its disadvantages that it cannot be employed in the presence of organic material, which must first be destroyed by $KClO_3$ and HCl, and that it shows antimony as well as arsenic.

How can the stains of As and Sb on the porcelain produced by Marsh's test be differentiated?

Arsenic stain is instantly soluble in NaClO, antimony is not; As stain dissolves slowly only in NH_4HS, Sb instantly; As stain dissolved in HNO_3 and evaporated gives a brick-red stain with $AgNO_3$, Sb does not. The mirror in the tube, if As, is beyond the flame; if Sb, nearer and on either side of the flame, and may be differentiated as above.

What is the comparative sensitiveness of Reinsch's and Marsh's test?

Reinsch's shows $\frac{1}{10000}$ grain; Marsh's $\frac{1}{50000}$ grain.

How is As determined quantitatively by Marsh's test?

By letting the AsH_3 pass through an excess of $AgNO_3$ solution until no further precipitation takes place. After this the excess of $AgNO_3$ is precipitated by NaCl, the liquid filtered, and the filtrate precipitated by H_2S, the resulting As_2S_3 is then dried and weighed, 5 parts of the sulphide corresponding to 4 As_2O_3.

Antimony.

What is antimony?

An elementary, crystalline, bluish-white solid, of metallic lustre, $Sb^{III\ V}$, a. w. 120, sp. gr. 6.7, fuses at 430° C.

What are its chemical properties?

It exhibits the metallic character more so than arsenic, combines directly with the halogens, and is oxidized by HNO_3. It volatilizes at a bright-red heat, burning in the air to antimony trioxide Sb_2O_3.

How does it occur in nature, and what is its use in the arts?

It is found in nature as black sulphide, termed crude antimony or black antimony, and is used in the arts as an alloy, principally in type-metal.

What is the hydrogen compound of Sb?

Hydrogen antimonide or stibine SbH_3, a colorless gas which burns with a greenish flame when ignited. It is not so poisonous as AsH_3, and when conducted through a solution of $AgNO_3$ it forms a black precipitate, but not of silver, as in the case of AsH_3, but of silver antimonide.

$$3AgNO_3 + SbH_3 = 3HNO_3 + SbAg_3.$$

Like AsH_3 when a piece of cold porcelain is introduced into its flame, it gives a dark stain, and when heated to redness it deposits elementary Sb.

What compounds of Sb are used in medicine?

Antimony trichloride, *butter of antimony*, $SbCl_3$, in the liquor antimonii chloridi used as an escharotic; *antimony trioxide* Sb_2O_3 in pulvis antimonialis; *antimony sulphide* Sb_2S_3; *antimonium sulphuratum*, a mixture of Sb_2S_3 with Sb_2O_3 in Plummer's pill, and a compound of similar composition, termed antimonii oxysulphuretum or Kermes mineral; also the *antimonii et potassii tartras*, tartar emetic, in vinum antimonii, unguentum antimonii tartratis, syrupus scillæ compositus.

What is tartar emetic and its properties?

It is the most common of the antimonial compounds used in medicine; KSbO.T a crystalline white substance, of metallic taste, freely soluble in water with acid reaction, and chars when heated to redness.

What are the symptoms of poisoning by tartar emetic?

Metallic taste, nausea, vomiting, purging, pain in epigastrium, intense thirst, as with As, cardiac depression, cramps, convulsions, collapse; fatal dose from gr. ii to ℥ss may produce death in from 7 hours to 4 weeks.

What is the treatment for poisoning by antimony?

Favor emesis or induce it by diluent drinks, strong tea, tannin, ferric hydrate if doubt as to As. After the more stormy symptoms have subsided the great danger is cardiac depression, which must be met with stimulants.

How does tartar emetic act if continued for some time?

It gives rise to perverted health and gradual exhaustion.

How is Sb detected in suspected chronic poisoning?

Obtain vomit or urine for several days; concentrate this and acidulate with HCl. Put some on a bright platinum dish and touch for a little while with a slip of zinc, when a black stain of antimony will form on the platinum, soluble in ammonium sulphydrate, and leaving, on evaporation, an orange-yellow stain.

How can Sb be also detected in concentrated urine or other liquids?

By Reinsch's or Marsh's test, also by dipping pure tinfoil in the acidulated solution when it will be coated with Sb if present. In all cases antimony itself must be produced and verified with ammonium sulphydrate.

How can Sb be detected by H_2S?

H_2S conducted through an acidulated solution of Sb will throw down a reddish-yellow amorphous precipitate of Sb_2S_3, soluble in NH_4HS, insoluble in NH_4HO. This has to be reduced by flux and made to appear as Sb mirror.

How can Sb be determined quantitatively?

By weighing the Sb_2S_3; 100 parts equal 196.4 $KSbO.\bar{T}$. The Sb_2S_3 may also be dissolved in HCl and then recovered as Sb with Reinsch's test, the increased weight of the copper slips giving the amount of Sb present.

Boron Group.

What elementary substance constitutes this group, and why?

Boron, B^{III}, a. w. 11, sp. gr. 2.68, a greenish-brown solid body, amorphous or crystalline; on account of its chemical properties it cannot be classed with other elements.

What is the principal boron compound of medical interest?

Boric acid H_3BO_3, occurring free in nature; it comes in white crystalline scales, soluble in 25 parts of water, and is also insoluble in alcohol. It reddens litmus paper, turns turmeric brown, and its alcoholic solution burns with a green flame; it is a valuable antiseptic.

What chemical change does boric acid undergo on heating?

At 100° C. it loses one molecule H_2O, ($H_3BO_3—H_2O=HBo_2$) forming meta-boric acid HBO_2; heated to 140° C. it forms tetraboric acid $H_2B_4O_7$.

What is the principal salt of $H_2B_4O_7$?

Its sodium salt termed borax $Na_2B_4O_7$, which occurs in nature and finds large application in medicine and the arts.

Electronegative Tetrads or Carbon Group.

What elements constitute this group?

Carbon and silicon.

Carbon.

What is carbon?

An elementary solid, $C^{II \& IV}$, a. w. 12, occurring in three principal allotropic modifications; it is not fusible nor volatile.

What are the principal forms carbon is found in?

Diamond, a crystalline substance of the monometric system, of great lustre and hardness, sp. gr. 3.5, good conductor of heat and electricity, combustible at intense heat to CO_2.

Graphite, a leaden gray, usually amorphous, substance of unctuous touch, sp. gr. 2.25, good conductor of heat and electricity; occasionally found crystalline in hexagonal plates, combustible with difficulty; it is sometimes termed plumbago, and used for making lead pencils.

Amorphous carbon, the product of incomplete combustion of organic bodies; also found in the fossil state.

Name the different varieties of amorphous carbon.

Soot or lampblack, vegetable coal or charcoal, animal coal or boneblack, gas carbon or plumbagine, bituminous or soft coal, also cannel coal, coke, and anthracite or hard mineral coal.

Describe lampblack and its use.

The carbonaceous matter condensed from the incomplete combustion of resins and hydrocarbons, etc., a finely divided form of carbon used for making printing and marking inks.

Describe charcoal and its use.

The product of incomplete combustion of wood, has a black color, is odorless, tasteless, sp. gr. 1.7; it is very porous, and can absorb many gases and vapors (90 volumes NH_3, 55 H_2S, 9 O_2); it is a powerful disinfectant. When saturated with one kind of gas it can still take up others; it contains condensed oxygen which can oxidize decaying matter and decolorize organic colors.

Describe animal charcoal, its manner of purification and use.

A similar production from bone as charcoal from wood; it is purified by treating it with HCl, and used as an antidote for alkaloidal poisons, which it absorbs.

Describe gas carbon and its use.

The carbon deposited in gas retorts, very hard, of metallic lustre, good conductor of electricity, therefore used in galvanic batteries.

Describe the principal varieties of mineral coal.

Fossil coal in its different varieties containing C, N, H, O, and S, besides mineral ash. Bituminous coal is rich in hydrocarbons, and when incompletely combusted leaves coke. Anthracite is the purest variety of mineral coal, is a good conductor of heat, and contains about 96–98 per cent. of pure C.

What are the compounds of carbon with hydrogen, and under what head are they generally considered?

Hydrocarbons, which, together with their derivatives, are generally considered under the head of organic chemistry. (*See* Hydrocarbons and their derivatives.)

Which are the oxygen compounds of carbon?

Carbon dioxide CO_2, carbon monoxide CO.

What is carbon dioxide, and what else is it called?

Carbon dioxide, CO_2, also termed carbonic anhydride or carbonic acid gas, is a colorless gas of slightly pungent odor and acid taste.

State the physical properties of CO_2.

It is heavier than air, sp. gr. 1.524, and can therefore be poured from one vessel to another; it will dissolve in equal volumes of water without pressure and much more with pressure. It condenses under a pressure of 36 atmospheres at 0° C. to a colorless mobile liquid, which, when allowed to evaporate, leaves portions of the CO_2 as a snow-like solid.

What are the chemical properties of CO_2?

It is neither combustible nor a supporter of combustion, unites with water to form carbonic acid, $CO_2+H_2O=H_2CO_3$, which forms carbonates with the bases, is dibasic, and produces both acid and normal salts.

$$KOH+H_2CO_3=KHCO_3+H_2O \text{ ; also : } 2KOH+H_2CO_3=K_2CO_3+2H_2O.$$

How is CO_2 prepared?

By the decomposition of carbonates by acids. In the gazogenes by tartaric acid and sodium bicarbonate, similarly in the effervescent powders of the Pharmacopœia, but for laboratory use or the manufacture of carbonic acid waters by the decomposition of marble (calcium carbonates), with hydrochloric or sulphuric acid.

$$CaCO_3+2HCl=CaCl_2+H_2O+CO_2.$$

Is Co_2 found in nature and where? How does it result?

It is found in nature as resulting from the direct combustion of carbon, also the decomposition of $CaCO_3$ by heat to form lime ($CaCO_3=CaO+CO_2$), as resulting from terrestrial exhalations in caves and mines, when it is called choke-damp; it also results from fermentation in cellars and brewery vats; it is found free in the atmosphere in the proportion of about 0.05 per cent. volume.

Where else does Co_2 result from, in what amounts, and how can its presence be proven?

CO_2 also results as a consequence of the oxidation of the food and tissues in the body, and is exhaled as waste product by the lungs, the respired air containing about 4 per cent. volume. Its presence can be proven by breathing into lime water (calcium hydrate $Ca(OH)_2$), which will be rendered turbid by the insoluble $CaCO_3$ formed; this will be redissolved by an excess of H_2CO_3.

How is CO_2 principally used in medicine and dietetics?

As carbonic acid waters or sparkling wines impregnated with CO_2 under pressure; it imparts to them a refreshing, biting, sparkling taste, and acts as sedative to the gastric mucous membranes; also in malt liquors where it results from fermentation.

What is the effect of pure carbon dioxide when inhaled?

It produces spasm of the glottis.

When diluted with atmospheric air how does it act, and what amount of dilution will produce this effect?

It will asphyxiate persons even when as little as 5 to 8 per cent. is contained in the atmosphere.

How is CO_2 detected in caves, wells, vats, etc.?

By lowering a lighted candle into them, which, if over 10 to 12 per cent. CO_2 is present, will be extinguished. If it burns dimly even, it is unsafe to descend into them, as the candle will burn where man cannot live.

What is the amount of CO_2 in the atmosphere, and why does it not increase?

The amount of CO_2 in the atmosphere is about 4 parts by volume in 10,000. This is quite constant, as the CO_2 generated in the various ways is absorbed by plants and also inorganic material.

To what is the vitiation of the atmosphere in crowded rooms due?

Partly to the carbonic dioxide exhaled by the persons in them and that generated by the burning of lights therein, also to the organic exhalations from the lungs.

What is the smallest amount of space permissible for each occupant of dormitories?

The space for each individual should not be less than 400 cubic feet, but for the sick, and especially those suffering from offensive diseases, it should be at least two or three times as much.

How does CO_2 act as a poison?

It acts similar to water in drowning persons by keeping the oxygen of the air from reaching the hæmoglobin of the blood, and preventing the elimination of the CO_2 produced in the blood and tissues.

How are persons overcome by CO_2 to be treated when in inaccessible localities?

If they cannot be reached or removed from the place, by adding freshly burned charcoal, which absorbs 35.5 volumes of the CO_2, and by so doing sets up a current of air towards him, also by freshly slaked lime or forcing in currents of fresh air; if removed therefrom, by artificial respiration, cold douche, faradism, friction, etc.

What is carbon monoxide?

Carbon monoxide or carbonous oxide, also improperly termed carbonic oxide, is a compound of divalent carbon with oxygen, CO^{II}, m. w. 28. A colorless, odorless, tasteless gas, little soluble in water, sp. gr. 0.969.

How is it prepared, and how does it ordinarily result?

It is prepared either by passing CO_2 over heated charcoal $CO_2 + C = 2CO$, or by heating oxalic acid with strong sulphuric acid, the latter decomposing and withdrawing H_2O, and liberating CO_2 and CO; $H_2C_2O_4 = H_2O + CO_2 + CO$. It results ordinarily by incomplete combustion of coal, as noticeable in coal stoves after the draft has been shut off, also in burning charcoal in the charcoal basins without fanning.

What are the chemical properties of Co?

It does not support combustion, but is combustible, burning with a blue flame to CO_2, reduces many metallic oxides at red heat, and as an unsaturated compound unites with other elements directly.

How does it act as a poison?

It acts as a direct poison, paralyzing the red corpuscles, and destroying the function of hæmoglobin as an oxygen carrier, by uniting with it to form carbonic-oxide hæmoglobin, which cannot again form oxyhæmoglobin.

What is its effect when inhaled in small quantities?

It produces languor, debility, anæmia, and its accompanying symptoms; as little as 0.5 per cent. will kill a bird.

Why is coal gas poisonous, and why is water gas more so than the former?

Because coal gas contains about 5 per cent. CO, and water gas about 27 to 30 per cent.

How can CO be determined quantitatively?

By agitating the gas or air to be examined in a eudiometer with an ammoniacal solution of cuprous chloride, which will absorb it and indicate the amount by the difference of volumes after opening it under water.

How is carbon monoxide detected in the blood after death?

The blood has a bright-red color; when examined with the spectroscope it presents bands similar to oxyhæmoglobin; the latter, however, can be converted to reduced hæmoglobin by reducing agents, but the carbonic oxide hæmoglobin remains unaltered when thus treated.

How are cases of poisoning by CO to be treated?

Removing the gas present in the lungs by artificial respiration; this is not curative however. Transfusion of blood would be indicated here, also inhalation of oxygen, but principally liberal and readily assimilated foods, stimulants, and iron.

What are the compounds of carbon with sulphur?

Carbon disulphide CS_2 and carbon oxysulphide COS.

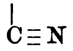
What is carbon disulphide?

A colorless, mobile liquid, of high refractive power, peculiar disagreeable odor, CS_2, m. w. 76, sp. gr. 1.27, boiling at 46° C.; it burns with blue flame to CO_2 and SO_2, dissolves iodine with violet color; also dissolves phosphorus, sulphur, caoutchouc, fats, and oils.

What compound does carbon form with nitrogen?

Cyanogen gas, C_2N_2, m. w. 52; a colorless gas, of penetrating, pungent odor, similar to that of peach kernels; sp. gr. 1.806; coercible, soluble in water, burning with purple-red flame to CO and N.

What is C_2N_2 really, and in which form found in compounds?

C_2N_2 is really dicyanogen of the graphical formula  $\begin{array}{c} C\equiv N \\ | \\ C\equiv N \end{array}$ and is met with in compounds as the univalent radical cyanogen Cy or $—C\equiv N$, which behaves chemically like the halogens, forming binary compounds with the metals, such as KCy, AgCy, and forms a binary acid with H, *i. e.*, HCy, also ternary acids, such as cyanic acid HCNO, and sulphocyanic acid HCNS.

What is hydrccyanic acid?

Hydrogen cyanide, also termed Prussic acid, HCN or HCy, a colorless, mobile liquid; boiling at 27° C.; of the specific odor of peach kernels.

How is HCy formed, and how made?

It forms by the action of the emulsion of bitter almonds on the amygdalin contained therein, in a similar manner also in cherry laurel leaves, peach kernels, wild cherry bark, etc. It is also found in the essential oil of bitter almonds. It can be made by decomposing a cyanide KCy or AgCy with a stronger acid, $2KCy + H_2SO_4 = K_2SO_4 + 2HCy$.

State the strength of U. S. and of Scheele's HCy.

The hydrocyanic acid of the U. S. Ph. contains 2 per cent. of HCy, Scheele's acid 5 per cent. The Pharmacopœial preparation is unstable, and therefore of uncertain strength.

What is the toxic effect of HCy?

Hydrocyanic acid in solution, in vapor form, or as soluble cyanide, is very poisonous, death taking place, as a rule, within a short time, preceded by convulsions, unconsciousness, slow and labored respiration, cold extremities, dilated pupils; generally the patient is dead before aid is rendered; but if he survives one hour there is hope of recovery on account of the volatility of the poison.

What is the treatment of poisoning by HCy?

Cold affusions, ammonia, galvanism, stimulants, atropine, chlorine developed from bleaching powder and vinegar. Smith's antidote, composed of ferrous and ferric salts, in presence of alkaline carbonates forms non-poisonous Prussian blue.

How is HCy detected after death?

1. By the probable presence of its characteristic odor. 2. By placing the part to be examined, after acidulation, in a jar, and this in warm water, and then cover the jar with a glass plate

moistened with $AgNO_2$; if HCy is present a white film of AgCy will form; this is not soluble in cold HNO_3 or only sparingly in NH_4HO. 3. Proceed in the former manner, but moisten the glass plate with KOH, instead of $AgNO_3$, and touch with a ferric and ferrous salt, which, on addition of HCl, gives rise to a deep blue color. 4. Moisten the glass plate as in the foregoing tests, but with ammonium sulphydrate, and then test with solution of ferric chloride, which, if HCy is present, gives rise to a red color, readily discharged on addition of a solution of mercuric chloride. This is due to ammonium sulphocyanide being formed, and saliva containing it gives the same reaction. Meconic acid also gives rise to a red color with ferric chloride, but it is not discharged on addition of $HgCl_2$.

What is the oxyacid of $(CN)_2$, and what compound does it form with ammonium?

Cyanic acid HCNO, which forms ammonium cyanate NH_4CNO with ammonium.

Of what interest is ammonium cyanate?

Because it is isomeric with and convertible into carbamide or urea CON_2H_4.

What is isomerism?

When two substances are composed of the same kind and number of atoms, but of different physical characters, owing to the different arrangement of their atoms in the molecule.

State and explain the two kinds of isomerisms.

Metamerism, when bodies of different physical character correspond in centesimal composition and molecular weight, and polymerism when they correspond in centesimal composition, but their molecular weights are different, the one being the multiple of the other.

Give the formula of sulphocyanic acid, name its salts, and which occur in the body.

Sulphocyanic acid HCNS; forms sulphocyanides; potassium and sodium sulphocyanide are found in the saliva, and give red color with ferric chloride, which is discharged by mercuric chloride.

Which are the principal metallocyanides and their use?

Potassium ferrocyanide, K_4FeCy_6, yellow prussiate of potassium, which gives blue precipitate of Prussian blue with ferric salts and potassium ferricyanide, $K_6Fe_2Cy_{12}$, red prussiate of potassium, which, with ferrous salts, gives a dark blue precipitate of Turnbull's blue.

Silicon.

What is silicon?

An elementary solid, Si^{IV}, a. w. 28.

Which compound of silicon is most abundant?

Silicic oxide SiO_2, m. w. 60, is found abundantly in minerals, quartz, rocks, and sand: it is found in all natural waters and in the cereals. Combined with water it forms acids which yield silicates.

What silicates are of interest in medicine?

The sodium or potassium silicates Na_2SiO_3, K_2SiO_3, which are soluble in water, and are used for fixing surgical dressings under the name of liquid glass.

What other silicates find common use?

The mixed silicates of sodium and calcium, or potassium and calcium, or lead and potassium, under the name of glass.

What are the different varieties of glass, their composition, and use?

Soda or soft glass, composed of sodium and calcium silicates, fuses readily, used for window and ordinary glass vessels. *Potash, Bohemian*, also hard glass, composed of potassium and calcium silicates, not very fusible, are used for the manufacture of chemical glassware. Crystal or flint glass, composed of lead and potassium silicates, fuses more readily, refracts light, and acquires a clear lustre; it is used for lenses and optical purposes, etc.

Metals of the Alkalies.

Which are the metals belonging to this group and their common characteristics?

Potassium, sodium, lithium, rubidium, cæsium, and ammonium. This latter though a compound is generally grouped with them. They are all soft, fusible, and volatile, have great affinity for oxygen, decompose water, readily forming basic oxides which with water yield caustic hydrates; they form soluble carbonates and only one chloride.

Potassium.

What is potassium?

A waxy, bluish-white metallic element K^I, a. w. 39, sp. gr. 0.865, melting at 62.5° C., distilling at red heat.

What are its chemical properties?

It has a great affinity for O, tarnishes in the air, and if thrown on water it decomposes it; $K+H_2O=KOH+H$ liberating H which ignites and burns with a violet flame. It has to be kept immersed in a hydrocarbon on this account.

Where and how is K formed?

Potassium exists in nature only in compounds, both in minerals as well as in plants, from the latter of which it is largely obtained by leaching out their ashes after combustion; it is then termed potash or pearlash, which consists principally of K_2CO_3.

How is K separated from K_2CO_3?

By reduction of the carbonate with charcoal and distilled over $K_2CO_3+2C=2K+3CO$.

When metallic potassium is thrown on water how is the water affected after the reaction, and why?

The water will become alkaline after reaction on account of the formation of potassium hydrate KOH.

What is potassium hydrate?

Potassium hydrate or hydroxide, also termed caustic potash KOH, m. w. 56.7, is a white crystalline mass which deliquesces readily, absorbing H_2O and CO_2; it has a strong alkaline reaction, is readily soluble in alcohol and water, and, from being cast in moulds, comes usually to market in thin sticks.

How is KOH prepared?

By decomposing the carbonate with calcium hydrate and evaporating the clear solution to dryness. $K_2CO_3+Ca(OH)_2=CaCO_3+2KOH$.

What is the officinal solution of KOH?

An aqueous solution of potassium hydrate termed liquor potassæ containing about 5 per cent. KOH, sp. gr. 1.036; 28 grams should require not less than 25 c.c. of the volumetric solution of oxalic acid for neutralization.

How is the strength of alkaline solutions determined?

By alkalimetry with a volumetric solution of oxalic acid, *q. v.*

How is the process of alkalimetry performed?

A certain amount of the alkaline solution to be tested, say 10 c.c., is placed in a beaker glass diluted, and to it are added a few drops of blue litmus solution as an indicator; then the volumetric solution of oxalic acid is dropped into it until the change of color of the litmus to violet denotes the neutralization. The result is then computed either by stoichiometric proportion or by reference to already computed tables, or expressed simply in the quantity of oxalic acid solution used.

What is the action of KOH on the tissues?

It dissolves and destroys them.

What class of poisons does it belong to, and what others belong to this class?

The alkaline caustics, made up of potassium hydrate, sodium hydrate, and ammonium hydrate.

State the symptoms produced by this class of poisons.

Acrid taste, burning sensation in mouth and œsophagus, constriction of fauces, inability to swallow, intense pain in stomach, abdominal tenderness, purging, prostration, mouth and tongue covered with white blisters and eschars. If the patient survives there may be sloughing followed by stricture of the œsophagus and a white waxy appearance from inanition.

What are the antidotes for poisoning by the alkaline caustics?

Diluted vinegar, lemon juice, or other mild vegetable acids, also oils, fats, or milk.

What are the tests for potassium hydrate?

Alkaline reaction, absence of effervescence when neutralized with acids, violet color of non-luminous flame when platinum covered with it is introduced. Neutralized with HCl, a yellow precipitate with platinum chloride ensues.

Which are the potassium compounds with the halogens?

Potassium chloride KCl crystallizes in vitreous cubes, sp. gr. 1.84, found in the blood. Potassium bromide KBr obtained together with potassium bromate, $KBrO_3$, by the action of bromine on potassium hydrate, crystallizes in cubes, sp. gr. 2.24. Potassium iodide, KI, crystallizes in cubes, sp. gr. 2.9, dissolves in 0.7 parts of water. Potassium fluoride KFl crystallizes in cubes, is very soluble in water, and etches glass.

How are KBr and KI chemically distinguished?

Their solutions when decomposed by Cl, give in the case of KBr, Br, recognized by giving a yellow compound with starch water, and in the case of KI, a blue starch iodide ; the iodine liberated in this latter test can also be shown by the violet color imparted when shaken with CS_2 or with chloroform.

What is potassium cyanide?

A compound of K with Cy, KCy, a white fusible mass, deliquescing in air, of the odor of prussic acid, is very poisonous like HCy only slower ; treatment for poisoning by it is as in HCy.

Which is the officinal potassium sulphide?

The liver of sulphur or potassium pentasulphide K_2S_5.

What is potassium hypochlorite?

A compound of K with HClO, which exists only in solution, known as Eau de Javelle, which has a chlorine odor, and is a powerful bleaching and disinfecting agent.

What is potassium chlorate?

A salt of chloric acid $HClO_3$, in which the H is replaced by K, formula $KClO_3$; crystallizes in shining tablets, not readily soluble in water. It has a saline, cooling taste, is astringent, and is used to make oxygen, *q. v.*; it is used internally, and also as a gargle, etc; is poisonous in over doses, and after death is found in the kidneys; it explodes violently when heated or rubbed up with oxidizable substances, and should not be prescribed with these in powder form.

Which are the two sulphates of potassium?

Neutral potassium sulphate K_2SO_4, crystallizes in rhombic prisms, of a bitter, saline taste, formerly employed in making Dover's powder. Acid potassium sulphate $KHSO_4$, crystallizes in rhombic tablets, readily soluble in water.

Describe the salt known as saltpetre, and its use.

Potassium nitrate KNO_3, also termed nitre; the result of the decay of nitrogenous substances in presence of potassium carbonate, this process being artificially employed for its production. It crystallizes in six-sided rhombic prisms, has a cooling taste, fuses at 3.38° C., and at higher heat gives off oxygen. It is principally used in the manufacture of gunpowder; it is poisonous in over doses. Antidote: emetics and raw eggs.

What two chromates of potassium are there?

Potassium chromate, also termed neutral potassium chromate, K_2CrO_4, yellow rhombic crystals, used as an indicator in the determination of chlorides. Potassium dichromate $K_2Cr_2O_7$, also called acid or red potassium chromate, crystallizes in large red triclinic prisms. It is used with H_2SO_4 in battery fluid. It is an active poison. Antidote: magnesia and alkaline earths.

What is potassium permanganate?

$KMnO_4$, crystallizing in dark-purple prisms, soluble in water with a beautiful purple color; a valuable oxidizing agent and disinfectant, oxidizing organic matter and forming brown manganese sesquioxide. Its solution in water is known as Condy's fluid.

Which are the two carbonates of potassium?

The neutral potassium carbonate, salt of tartar, or pearlash K_2CO_3, a white granular deliquescent powder, readily soluble in water with alkaline reaction, and the hydropotassium carbonate or acid potassium carbonate, also termed potassium bicarbonate $KHCO_3$, crystallizing in monoclinic prisms, not so readily soluble in water as the normal salt.

What is potassium citrate?

The potassium salt of citric acid, abbreviated formula, $K_3\overline{C}$; officinal in the liquor potassii citratis, also the mistura potassii citratis; it is antifebrile, and renders the urine alkaline by being converted into carbonates.

Potassium acetate, what is it?

A potassium salt of acetic acid $KC_2H_3O_2$ or $K\bar{A}$; crystalline and very deliquescent; it is diuretic and laxative.

Which is the principal potassium oxalate?

The acid potassium oxalate or binoxalate of potassium KHC_2O_4; a mixture of this with the quadroxalate is known as salt of sorrel or salt of lemon, used for removing ink stains; resembles Epsom salts in appearance, and often mistaken for it. It is poisonous, the same as oxalic acid, *q. v.*

What is potassium tartrate, and what acid potassium tartrate?

Potassium tartrate or soluble tartar results when two H of tartaric acid are replaced by K; $K_2C_4H_4O_6$; it is very soluble in water. Acid potassium tartrate or potassium bitartrate, also termed cream of tartar, the salt resulting when only one H of tartaric is replaced by K; it crystallizes in rhombic prisms, only slightly soluble in water, and of acid reaction.

From what is cream of tartar made?

From argols, the impure acid potassium tartrate deposited from the grapes in the casks during vinous fermentation.

How are potassium compounds recognized?

They are mostly readily soluble in water. Tartaric acid will give with concentrated solutions a white precipitate of acid potassium tartrate; introduced into a non-luminous flame, they give rise to a violet coloration. The spectrum exhibits one red and one violet line.

Sodium.

What is sodium?

A silver-white, soft, elementary metal Na^{I}, a. w. 53, sp. gr. 0.98; fusing at 97° C., and distilling over at red heat. It oxidizes and tarnishes readily when exposed, decomposes water disengaging H, and has to be preserved under a hydrocarbon. It burns with a yellow flame.

How is sodium prepared?

Like potassium, by heating sodium carbonate and charcoal to a white heat in an iron retort, when it distils over.

Where and how does sodium occur?

It is abundant as chloride in rock salt, also in sea-water and saline springs; also in deposits, as sodium nitrate and borate.

What is sodium hydrate?

Sodium hydrate or hydroxide, also termed caustic soda, $NaOH$, is a white, crystalline substance, usually found in the market in cylindrical sticks presenting radiating crystalline fractured surfaces, attracts moisture, and on exposure changing on the surface to sodium carbonates. Its solution in water is known as soda lye, the officinal solution as liquor sodæ.

What are the properties of liquor sodæ, and how is it prepared?

It is an aqueous 5 per cent. solution of $NaOH$, sp. gr. 1.059, 20 grams should not require less than 25 c.c. of volumetric solution of oxalic acid for neutralization; it belongs to the caustic alkaline poisons, producing the same symptoms as KOH and requiring the same antidote. It is prepared similarly as KOH from Na_2CO_3 and $Ca(OH)_2$; $Na_2CO_3 + Ca(OH)_2 = CaCO_3 + 2NaOH$.

What is the respective physiological effect of potassium, and what of sodium compounds?

Potassium compounds are heart and muscle poisons, while those of sodium are inert.

What is the chlorine compound of sodium?

Sodium chloride, common or table salt, $NaCl$, crystallizing in transparent cubes, sp. gr. 2.13, soluble in about 3 parts of water.

What is the function of NaCl in the animal economy?

It is found in all tissues and liquids of the body, especially in the blood. It is ingested with the food and principally eliminated by the kidneys. In the tissues it tends to promote cell nutrition by conducting the osmotic process; it appears in all excretions but chiefly in the urine.

In what quantities is NaCl, or chlorides represented by it, eliminated in 24 hours?

The total chlorides of the urine eliminated in 24 hours, consisting principally of sodium and potassium chlorides, average about 12–16 grams.

What influences the amount of chlorides present in the urine?

The amount ingested, also the condition of health; thus in febrile diseases they are diminished, especially when these are due to inflammatory exudations; *e. g.*, in pneumonia, they may be almost or totally absent and reappear with a limitation of the inflammatory process.

How is the presence of chlorides in the urine demonstrated?

By adding first a few drops of HNO_3, to prevent the precipitation of the phosphates, and then adding a solution of silver nitrate, when a more or less dense precipitate of silver chloride will indicate approximately the amount of chlorides present: $NaCl+AgNO_3=NaNO_3+AgCl$.

How are the chlorides in the urine volumetrically determined?

With a solution of silver nitrate standardized to precipitate accurately 0.01 $NaCl$ for each c.c. (29.06 $AgNO_3$ to 1 liter H_2O.)

Describe the process for determining volumetrically the amount of chlorides in urine.

Dilute 10 c.c. urine with 50 c.c. water in a porcelain dish or beaker, add a few drops of neutral potassium chromate solution to give it a distinctly lemon-yellow color. Allow the silver nitrate solution to gradually flow into it, while stirring, until the urine turns permanently orange-red. Each c.c. of the silver solution used indicates 0.01 NaCl present in the 10 c.c. urine, or ten times the total number of c.c. the percentage of chlorides expressed in NaCl, subtracting one c.c $AgNO_3$ solution for supersaturation.

If the urine is highly colored or putrid or albuminous, what should first be done?

The organic matter should be oxidized with potassium permanganate solution gradually added while boiling until a faint pink hue remains ; the resulting manganese sesquioxide is then filtered off, the quantity brought up to the original volume with distilled water, and proceeded with as above.

What is sodium bromide?

A binary compound of sodium and bromine NaBr, soluble in 1.13 parts of water at 20° C., and representing 77.67 per cent. Br.

What binary compound does Na form with I?

Sodium iodide NaI, dissolves in 56 parts of water at 20° C., and represents 84.6 per cent. iodine.

What is sodium hypochlorite, and in what preparation is it contained?

Sodium hypochlorite, NaClO, is contained in the liquor sodæ chloratæ or Labarraque's solution, prepared by decomposing a saturated solution of chlorinated lime with a solution of sodium carbonate. It is a powerful bleaching and disinfecting agent.

Give the formulæ of the chlorate, bromate, and iodate of sodium.

Sodium chlorate $NaClO_3$, sodium bromate $NaBrO_3$, sodium iodate $NaIO_3$.

Which is the principal sulphate of sodium?

The neutral sodium sulphate Na_2SO_4 known as Glauber's salt, crystallizing in large efflorescent prisms, which melt in their water of crystallization when heated.

How do the sulphates get into the blood, and how are they eliminated?

The sulphates of potassium and of sodium are in part directly derived from the foods, and also together with organic sulphur compounds from the oxidation of the albuminoids of the body. They are eliminated by the urine in quantities of about 3 to 4 grams in 24 hours.

How may the sulphates of the urine be demonstrated and approximated?

By acidulating the urine with a few drops of HCl and then adding a solution of barium chloride which causes a white precipitate; this may be compared for approximation with that from a known normal specimen of urine.

How are the sulphates determined volumetrically?

By acidulating 100 c.c. urine with HCl and boiling it. Into this drop gradually from a burette the standard solution of barium chloride (30.5 $BaCl_2$ in 1000 H_2O), until no further precipitate ensues, testing this frequently to attain accurate results. Each c.c. of the $BaCl_2$ solution used corresponds to 0.01 grm. SO_3, the total number of c.c. $BaCl_2$ used gives at once the percentage.

What are sodium sulphite and hyposulphite?

Sodium sulphite Na_2SO_3, the salt resulting when the H in H_2SO_3 is replaced by Na. Sodium hyposulphite $Na_2S_2O_3$ is a reducing agent and a disinfectant.

Which are the principal sodium phosphates?

The disodium phosphate or neutral sodium phosphate Na_2HPO_4, sodii phosphas U. S., slightly alkaline; and the monosodium phosphate or acid sodium phosphate NaH_2PO_4 of acid reaction.

When Na_2HPO_4 is heated what forms?

It loses water and forms sodium pyrophosphate $Na_4P_2O_7$.

Where is the Na_2HPO_4 found in the body and where the NaH_2PO_4?

The Na_2HPO_4 is found in all the tissues and liquids of the body but is converted into the NaH_2PO_4 by the $NaHCO_3$ of the blood and eliminated as such in the urine, to which the latter owes its normal acid reaction. $Na_2HPO_4+NaHCO_3=NaH_2PO_4+Na_2CO_3$.

Which are the two principal carbonates of sodium?

Sodium carbonate, sal soda, washing soda, Na_2CO_3, and hydrosodium carbonate, acid sodium carbonate, also sodium bicarbonate, $NaHCO_3$.

What is sodium carbonate? Where and how obtained?

Sodium carbonate is found free in nature, but mostly manufactured on a large scale from sodium chloride. It is a salt crystallizing with 10 Aq, in large efflorescent crystals, has a strong alkaline reaction and yields CO_2 when treated with acids.

What is sodium bicarbonate?

A salt manufactured by treating Na_2CO_3 with CO_2 ($Na_2CO_3+CO_2+H_2O=2NaHCO_3$), of feeble alkaline reaction, giving up CO_2 on heating and boiling forming Na_2CO_3; it crystallizes without water entering its molecule.

What officinal preparations does $NaHCO_3$ enter?

The soda powders (pulveres effervescentes) and the Seidlitz powders (pulveres effervescentes aperientes); the former containing $NaHCO_3$ and tartaric acid in different papers, the latter $NaHCO_3$ with Rochelle salt and tartaric acid, also in two separate papers.

How is $NaHCO_3$ used in baking?

To aerate, *i. e.*, raise the bread, hence its name salæratus or baking powder. It should be mixed for this purpose with either cream of tartar or tartaric acid sufficient to change it into a neutral tartrate, while the CO_2 given off will render the bread light and spongy.

What is Rochelle salt?

Sodium potassium tartrate $NaK\overline{T}. + 4Aq$. A double salt of tartaric acid, in which one H is replaced by K and the other by Na. It is prepared by neutralizing cream of tartar with sodium carbonate; it crystallizes in large transparent prisms, and is readily soluble in water.

How are sodium compounds recognized?

They are almost all readily soluble in water; inserted into a non-luminous flame they give rise to a yellow coloration, and, viewed through the spectroscope, they exhibit a yellow line.

Lithium.

What is lithium?

An elementary metal Li, a. w. 7, sp. gr. 0.59; the lightest of all metals known; found in compounds in various minerals and in the waters of some mineral springs.

What is lithium carbonate?

Lithium carbonate Li_2CO_3; a valuable antacid, rendering the urine alkaline, and forming soluble lithium urate with uric acid. It is a white, pulverulent substance, very little soluble in plain water, but considerably more so in carbonic acid water.

What is lithium bromide, and what its advantages over other bromides?

Lithium bromide LiBr is a crystalline substance, very deliquescent, containing more bromine than any other bromide (91.95 per cent.).

What are the characteristic flame reactions of Li compounds?

They produce, when inserted into non-luminous flames, a bright-red coloration, which, when viewed through a spectroscope, causes an intense red line in the spectrum.

Ammonium.

Why should ammonium, NH_4, be considered with the metals of the alkalies?

Because it shows in its chemical action much similarity to them, forming salts like them, and can be converted into an amalgam with mercury, NH_4Hg.

What is ammonium hydrate?

NH_4OH, formed by passing gaseous ammonia NH_3 into water, $NH_3 + H_2O = NH_4OH$; a clear liquid, of strong ammoniacal odor, lighter than water, of a strong alkaline reaction, which, on heating, is decomposed into NH_3 and H_2O.

What is aqua ammoniæ, and what aqua ammoniæ fortior U. S.?

Aqua ammoniæ is an aqueous solution of NH_3, sp. gr. 0.950, containing 10 per cent. by weight of the gas. Aqua ammoniæ fortior is the same, but has a sp. gr. 0.900, and contains 28 per cent. by weight of the gas.

To what class of poisons does NH_4OH belong?

To the caustic alkalies, producing the symptoms of these with greater respiratory disturbances, and requiring the antidotes already mentioned for this class (*see* Potassium hydrate).

Which are the principal halogen compounds of NH_4?

Ammonium chloride NH_4Cl, ammonium bromide NH_4Br, ammonium iodide NH_4I.

How is NH_4Cl prepared, and what are its properties?

Muriate of ammonia or sal ammoniac NH_4Cl is prepared by neutralizing NH_4OH with HCl; $NH_4OH + HCl = NH_4Cl + H_2O$; crystallizes in small feather-like forms, of a sharp, salty taste; dissolves readily in water, and sublimes without melting; heated with KOH, NaOH or $Ca(OH)_2$, it gives off NH_3.

What is ammonium hydrosulphide and its use?

Ammonium sulphydrate, NH_4HS, is a compound produced by saturating NH_4OH with H_2S; it is at first colorless, but becomes yellow. It is principally employed as a precipitant in the laboratory for analytical purposes.

What is ammonium sulphate?

$(NH_4)_2SO_4$, obtained by saturating NH_4OH with H_2SO_4; a crystalline salt, readily soluble in water.

What is ammonium nitrate, and its use?

NH_4NO_3, a salt produced by neutralizing NH_4OH with HNO_3, and crystallizing from its solutions in long six-sided prisms. It is very soluble in water, and fuses at 150° C., decomposing at 210° into nitrous oxide N_2O and water: this is utilized for the production of nitrous oxide for anæsthesia.

Where is ammonium nitrite found, and how formed?

It is found in the air after thunder-storms and in rain-water, resulting from the action of the electric spark on moist air.

Which are the carbonates of ammonium?

Neutral ammonium carbonate $(NH_4)_2CO_3$ decomposes readily into NH_3 and acid ammonium carbonate NH_4HCO_3. The ammonii carbonas U. S., or so-called ammonium sesquicarbonate, also sal volatile, is a mixture of the acid ammonium carbonate with ammonium carbamate $(NH_4HCO_3 + NH_4NH_2CO_2)$.

How can ammonium compounds be recognized?

They are colorless, volatile, and give off NH_3 when treated with bases. This may be recognized with moist litmus paper, which turns blue. With platinum chloride they give a yellow, crystalline precipitate.

Metals of the Alkaline Earths.

Which are the metals composing this group?

Calcium, strontium, barium.

What are the characteristics of the metals of this group?

They are divalent, form basic hydrates, and insoluble carbonates, phosphates, and sulphates.

Calcium.

What is calcium?

A light-yellowish metal Ca, a. w. 39.9, sp. gr. 1.5778, decomposes water, and burns with a bright light. It is abundant throughout nature in its compounds, principally as carbonate.

What is the principal calcium oxide, and how prepared?

Calcium oxide, also termed lime or quicklime, calx U. S. CaO is prepared from the native calcium carbonate $CaCO_3$ (limestone or marble), by heating it in kilns for that purpose. $CaCO_3 = CaO + CO_2$. From the air it attracts CO_2 and again forms $CaCO_3$.

Slaked lime, what is it chemically, and how obtained?

Slaked lime or calcium hydrate $Ca(OH)_2$ is a white amorphous powder, forming a milky paste with water (milk of lime), and dissolves in cold water, about 1 part in 760; this is termed lime-water, liquor calcis U. S., and prepared by the action of water on CaO; $CaO + H_2O = Ca(OH)_2$.

What is syrupus calcis?

A solution of $Ca(OH)_2$ in sugar and water. The addition of sugar makes the $Ca(OH)_2$ very much more soluble, 1 fluidounce containing about 8 grains.

If lime is taken in substance, what is the effect, and what the antidotes?

It acts as a caustic poison. Antidotes: diluted acids and oils.

What is calcium fluoride?

Fluorite or fluor-spar $CaFl_2$, used for obtaining hydrofluoric acid HFl.

What are the compounds of Ca with Cl, Br, and I?

Calcium chloride $CaCl_2$, calcium bromide $CaBr_2$, calcium iodide CaI_2.

How is calcium chloride prepared and how used?

It is prepared by the action of HCl on $CaCO_3$; $CaCO_3+2HCl =CaCl_2+H_2CO_3$. It is a crystalline deliquescent salt, which, when heated, loses its water of crystallization and appears in a fused state; it is used for freezing mixtures, also for desiccating gases.

What is chlorinated lime?

Bleaching powder or calx chlorata is probably a mixture of calcium hypochlorite $Ca(ClO)_2$ and calcium chloride $CaCl_2$ or CaClClO; it is prepared by passing chlorine over slaked lime;

$$2Ca(OH)_2+2Cl_2=Ca(OCl)_2+CaCl_2+2H_2O,$$

and is used principally as a bleaching and disinfecting agent, depending on the liberation of Cl by H_2CO_3 of the air or by other acids admixed with it.

Calx sulphurata U. S., what is it?

A mixture of calcium sulphide CaS and calcium sulphate $CaSO_4$, prepared by heating together lime and precipitated sulphur.

What is calcium sulphate, and in what form is it generally used?

Calcium sulphate in its crystalline form is known as gypsum $CaSO_4+2Aq$, and when dehydrated by calcination is known as plaster of Paris, used for fixed surgical dressings, as on mixing with water it again assumes its hydrated crystalline state.

What compounds does Ca form with phosphoric acid?

The acid calcium phosphate or monocalcium phosphate, also termed superphosphate of lime, $Ca(H_2PO_4)_2$; the di-calcium phosphate $Ca_2(HPO_4)_2+2H_2O$, and the tricalcium phosphate or neutral calcium phosphate, also termed bone phosphate and precipitated phosphate of calcium $Ca_3(PO_4)_2$.

Which of the three calcium phosphates is principally found in the body, and what part thereof?

All three are found in the body, but principally the neutral salt, which is contained in a large amount in the bones and the teeth; it is sometimes found in the urine, the acid salt being always present therein and forming there along with the magnesium phosphate the so-called earthy phosphates.

What is the total elimination of phosphoric acid by the urine in 24 hours, and what part of the phosphates so eliminated are phosphates of the alkalies, and how much earthy phosphates?

The total elimination of phosphoric acid in the form of phosphates is about 2-3 grams in 24 hours, two-thirds of which are alkaline and one-third earthy phosphates.

How can the earthy phosphates of the urine be separated?

By rendering the urine alkaline with KOH or NaOH, when, on heating, the earthy phosphates will separate out in flakes, and then can be removed by filtration.

After separation of the earthy phosphates how can the alkaline phosphates be precipitated?

By adding to the filtrate one-third of its volume of magnesia mixture the alkaline phosphates will be precipitated.

How can the total amount of phosphoric acid in urine be readily approximated?

By Teissier's method; in a graduated cylindrical vessel add 50 c.c. urine and 15 c.c. magnesia mixture, shake together and let stand for 24 hours, each c.c. of the deposit will represent approximately 0.30 grams P_2O_5 per liter or 0.03 per cent. thereof.

How is the total amount of phosphoric acid in urine determined by the volumetric process?

Take 50 c.c. urine in a suitable vessel, add 15 c.c. acidulated solution of sodium acetate and heat to the boiling point; then drop into the mixture from a burette, drop by drop, a standardized solution of uranium acetate (1 c.c. to represent 0.005 P_2O_5). Test frequently by dropping some of the heated mixture into a solution of potassium ferrocyanide; when a chocolate color precipitate begins to appear the process is finished. For each c.c. of the uranium acetate solution used count 0.005 grams P_2O_5 in the 50 c.c. urine, or twice as much to get the percentage.

How does calcium carbonate occur in nature?

$CaCO_3$ is abundant and in vast deposits known as chalk, limestone, and marble; it is also found crystalline as calc-spar, Iceland spar, and arragonite; the shells of crustacea, of birds' eggs, corals, and the bones and teeth of animals contain it.

What are the officinal forms of $CaCO_3$?

Precipitated chalk, calcii carbonas præcipitatus U. S., prepared by precipitating a solution of $CaCl_2$ with Na_2CO_3, and prepared chalk, creta præparata U. S., a native friable calcium carbonate freed from most impurities by elutriation.

What are the properties of $CaCO_3$?

It is almost insoluble in pure water, but soluble in water containing H_2CO_3, forming probably calcium hydrocarbonate or acid carbonate, also called bicarbonate of calcium. As many waters, streams, and springs are strongly impregnated with H_2CO_3 they hold $CaCO_3$ in solution and deposit it on evaporation, as illustrated by the formation of stalactites.

By which analytical reactions are calcium compounds recognized?

Solutions of calcium salts are precipitated by alkaline carbonates and phosphates; ammonium oxalate gives a white precipitate with them, insoluble in weaker acids, but soluble in strong HCl or HNO_3. With sodium tungstate they give dense white precipitates. Calcium salts color a non-luminous flame red.

Barium.

In which form does barium occur in nature, and what are its symbol and a. w.?

Barium is found exclusively as a native sulphate, which, on account of its great weight, is also called heavy spar and barytes; the native carbonate is termed witherite. The symbol of barium is Ba; a. w. 137; sp. gr. 3.6.

What are the oxides and what is the hydrate of barium?

There are two, barium oxide, also called baryta BaO, and barium peroxide BaO_2, used in making hydrogen peroxide. When barium oxide is dissolved in water it forms barium hydrate or hydroxide $Ba(OH)_2$, the solution being known as baryta water, which is strongly alkaline, and is rendered turbid by CO_2, insoluble $BaCO_3$ being formed.

What are the compounds of Ba with Cl and with HNO_3, and their use?

Barium forms a soluble crystallizable barium chloride, $BaCl_2$, with Cl, with HNO_3 it forms a soluble crystallizable barium nitrate $Ba(NO_3)_2$; both of these salts are used for the detection and determination of sulphuric acid and soluble sulphates.

What is the action of the soluble barium salts on the human economy?

They are actively poisonous. Antidotes: soluble sulphates.

How are the barium compounds recognized?

Their solutions give white precipitates with alkaline carbonates, also heavy white precipitates with H_2SO_4 or soluble sulphates, insoluble in acids, white precipitates with alkaline phosphates soluble in HNO_3; they color a non-luminous flame green.

Magnesium Group.

Which are the principal metals of interest in this group, and what are their common characteristics?

Magnesium, Mg, Zinc, Zn, Cadmium, Cd. They are all dyads forming but one oxide and one sulphide. Their oxides and hydroxides are almost all insoluble in water; they form soluble sulphates and insoluble carbonates and phosphates.

Magnesium.

What is magnesium?

A bright silver-white metal, Mg, a. w. 24, sp. gr. 1.75, burns when ignited with intense white light to magnesium oxide, MgO, dissolves readily in dilute acids forming salts, and is not attacked by alkalies.

When and how does magnesium occur in nature?

Its compounds abound in nature as carbonate, as silicate in talcum, soapstone, asbestos, and meerschaum, as soluble salts in most natural waters, and largely so in sea-water and some mineral springs; they are also present in the economy into which they enter by the foods and water, and are eliminated by the urine as phosphate.

What is magnesium oxide?

Magnesia or calcined magnesia MgO, obtained by calcining the hydrate or carbonate; a white, voluminous, amorphous powder, very insoluble in water; two varieties are used in medicine, of which the former is known as magnesia or magnesia levis, while the heavier article is known as magnesia ponderosa.

What is magnesium hydrate?

Magnesium hydrate or hydroxide $Mg(OH)_2$ is the precipitate resulting when a solution of a magnesium salt is decomposed by the hydrate of potassium or sodium; in suspension with water it is known as milk of magnesia.

What is magnesium chloride?

A very deliquescent salt $MgCl_2$, present in many mineral springs, and in some impure grades of table salt.

What is magnesium sulphate?

Magnesium sulphate, Epsom salt $MgSO_4 + 7Aq$, found in sea-water and in a number of mineral springs. It crystallizes in four-sided rhombic prisms, is readily soluble in water, has a bitter, saline taste, and finds much use as an aperient.

Which are the principal phosphates of magnesium?

The tri-magnesium phosphate $Mg_3(Po_4)_2$ in bones, the mono-magnesium phosphate $MgHPo_4+7Aq$ present in the urine; when it meets ammonium compounds, it forms the ammonium-magnesium phosphate $MgNH_4PO_4 + 6Aq$, also termed triple-phosphate.

$$MgHPO_4 + NH_4HO = MgNH_4PO_4 + H_2O.$$

What is the cause of the formation of triple-phosphate in the urine, and what is its significance?

When urine is decomposed by putrefactive change ammonium carbonate is formed, $CON_2H_4 + H_2O = (NH_4)_2CO_3$; this with magnesium phosphate yields ammonium-magnesium phosphate,

$$2MgHPO_4 + (NH_4)_2CO_3 = H_2CO_3 + 2MgNH_4PO_4,$$

which separates out in microscopic prismatic crystals resembling coffin lids. If these occur persistently, the liability to formation of fusible or triple-phosphate calculi arises.

Which are the principal carbonates of magnesium?

Neutral magnesium carbonate $MgCO_3$, which occurs in nature as magnesite. The magnesii carbonas of the Pharmacopœia is a mixture of magnesium carbonate with magnesium hydrate $(MgCO_3)_4Mg(OH)_2 + 5H_2O$; a white voluminous powder, usually offered in the market as light-white cubes. This, when suspended in water and carbon dioxide, is passed through it, dissolves and forms what is known as liquor magnesii carbonatis or fluid magnesia.

How are magnesium compounds recognized?

The alkaline hydrates precipitate from their solutions magnesium hydrate, the carbonates basic magnesium carbonate; the precipitates are insoluble in water, but soluble in solutions of ammonium salts from which di-sodium phosphate precipitates ammonium-magnesium phosphate.

Zinc.

What is zinc?

A bluish-white metal, Zn, a. w. 65, of crystalline fracture, sp. gr. 7–7.2; fuses at 412° C., and distils at about 1000° C. It is soluble in dilute acids with liberation of H, also in KOH or NaOH on boiling, when it yields H as with acids.

What is zinc hydrate?

A white amorphous powder $Zn(OH)_2$, precipitated by the decomposition of a zinc salt solution with an alkaline hydrate, in an excess of which it is freely soluble.

What is zinc oxide?

A white, tasteless powder, ZnO, insoluble in water, but freely soluble in acids, with which it forms salts; it turns yellow on heating, and white again on cooling. It is largely used in the arts for paint, as it will not darken on exposure to H_2S like the lead pigment; it is also employed in medicine, both internally as well as externally, in the unguentum zinci oxidi.

What is the chlorine compound of zinc?

Zinc chloride $ZnCl_2$, a white deliquescent fusible substance; it is a painful caustic; in solution, containing 50 per cent., it is known as liquor zinci chloridi; it is used as a flux for solder, also as a disinfectant (Burnett's disinfecting fluid); diluted it serves as a soft injection for the preservation of dead bodies.

What is the toxic action of $ZnCl_2$, and its antidote?

It coagulates albumen, hence its corrosive action, and again by absorption it manifests its specific action on the nerve centres, paralyzing motion, and causing tremor and coma. Antidotes: milk, eggs, and vegetable astringents.

What sulphide do neutral solutions of zinc salts yield with H_2S?

A white zinc sulphide ZnS.

What is zinc sulphate?

White vitriol $ZnSO_4$, crystallizing with 7Aq in rhombic crystals, resembling those of magnesium sulphate; it forms insoluble compounds with albumen and milk; it is a rapid, non-depressing emetic in doses of gr. xx–xxx.

How may the compounds of zinc be recognized?

Their solutions give a white precipitate with alkaline hydrates, soluble in excess; K_2CO_3 and Na_2CO_3 white precipitate, insoluble in excess; $(NH_4)_2CO_3$ white precipitate soluble in excess; H_2S white precipitate from neutral solutions; ammonium sulphydrate white precipitate, insoluble in excess of it, as well as in KOH, or NaOH, or NH_4OH; potassium ferrocyanide white precipitate, insoluble in HCl.

Lead Group.

Which are the metals of this group?

Lead and thallium.

Lead.

What is lead?

A bluish-white heavy metal, Pb, a. w. 207, soft and ductile, of bright lustre on freshly-cut surface, becoming tarnished after exposure; sp. gr. 11.37; fuses at 325° C.; forms alloys with other metals; among these is type-metal, composed of lead and antimony, and soft solder of lead and tin.

What is the principal source of lead?

Galena, a native lead sulphide, from which it is separated by roasting.

What is the action of water on metallic lead?

Pure water does not act on lead, but by the action of air and water, alternately, it becomes coated with lead hydrate $Pb(OH)_2$, which is somewhat soluble in water; thus new lead pipes may give rise to the contamination of water. If the water contains CO_2 and salts, the lead becomes coated with insoluble carbonate and sulphate, and old pipes therefore give greater immunity from contamination; however, by an excess of CO_2 the carbonate may be rendered slightly soluble. The presence of nitrates and nitrites in water conducted through lead pipes also tends to produce lead contamination in water.

What is lead hydrate?

$Pb(OH)_2$; a white precipitate thrown out from solutions of lead salts by alkaline hydrates; it renders water alkaline, and forms lead carbonate with CO_2.

Which are the principal oxides of lead?

Lead monoxide, PbO or litharge, lead peroxide or dioxide PbO_2, plumboso plumbic oxide Pb_3O_4 or minium.

What is lead monoxide?

PbO, litharge, is the officinal plumbi oxidum, produced by heating lead in the air, is a reddish-yellow substance, of rhombic scales, or when obtained as yellow amorphous powder it is known as massicot. It has strong basic properties, saponifies fats, producing with olive oil the emplastrum plumbi U. S., melts at red heat, and unites with silicic anhydride to form lead glass; it is employed thus to make the glaze on pottery: it is also used as a dryer for paints; it dissolves in water as hydrate, rendering it alkaline, and absorbs then CO_2; it also dissolves in hot solutions of KOH and NaOH, from which it crystallizes on cooling.

What is lead peroxide?

Lead peroxide or dioxide, PbO_2: a brown amorphous powder remaining when minium is treated with HNO_3. It has acid properties uniting when warmed with KOH to form potassic plumbate, $K_2PbO_3 + 3Aq$.

What is minium?

Red lead or minium is a bright red powder Pb_3O_4, a compound of lead oxide with lead peroxide $(PbO)_2PbO_2$. It is obtained by heating litharge to 300-400° C. in the air; it is used as a pigment for red paint.

What is lead chloride?

$PbCl_2$, the white precipitate resulting by adding HCl or a soluble chloride to solutions of lead salts. It is very little soluble in cold water, soluble in 30 parts of hot water, from which it crystallizes on cooling.

What is lead iodide?

PbI_2, the yellow precipitate resulting from solutions of lead salts when treated with potassium iodide; little soluble in cold but more freely soluble in boiling water, from which it crystallizes on cooling in beautiful six-sided plates discernible under the microscope; it is readily soluble in KOH.

When solutions of lead salts are treated with H_2S what results?

Lead sulphide PbS, a black amorphous powder, insoluble in dilute acids. In nature PbS occurs in cubic crystals of a metallic lustre, and is commonly known as galena.

If sulphuric acid or soluble sulphates are added to solutions of lead salts what results?

Lead sulphate $PbSO_4$, a white powder almost insoluble in water.

What is lead nitrate?

$Pb(NO_3)_2$, a crystalline salt resulting when lead is treated with HNO_3; it dissolves in 8 parts of water, and as such forms a disinfecting fluid called Ledoyen's solution.

When to a solution of lead salt potassium chromate is added what is formed?

Lead chromate, chrome yellow, $PbCrO_4$, a bright yellow amorphous powder, insoluble in weaker acids but readily soluble in KOH. It is used largely in the arts as a pigment, and has been used with fatal effect to give buns and cakes the yellow color of eggs.

Which is the principal lead salt used in medicine?

Lead acetate or sugar of lead $Pb(C_2H_3O_2)_2+3\ Aq$, also termed saccharum saturni, crystallizing in large, colorless prisms, of sweetish taste, acetous odor, acid reaction, and efflorescent on exposure; with water containing CO_2 it makes turbid solutions, lead carbonate being precipitated.

For what purposes is lead acetate usually employed?

In medicine as a sedative and astringent; it is generally found as an ingredient in the different hair-color restorers, and while not very actively poisonous itself it may become so if its use in such a manner is persistently continued.

When lead acetate in solution is boiled with lead oxide, PbO, what results?

The PbO is dissolved and a solution of lead subacetate or basic lead acetate is formed, which is known as the liquor plumbi subacetatis U. S., also termed Goulard's extract; when diluted it is known as the liquor plumbi subacetatis dilutus or lead water.

What is neutral lead carbonate?

Lead carbonate $PbCO_3$ is a white amorphous powder, different commercial forms of which are known as white lead, flake white, cremnitz white, etc., which are basic varieties; such is also the plumbi carbonas U. S. $(PbCO_3)_2Pb(OH)_2$.

For what purpose is the lead carbonate employed?

Principally as pigment and base for oil paints, for making plumber's joints, in medicine in ointment form, for glaze of paper, and frequently as a most objectionable cosmetic. It is the most poisonous of the lead compounds.

What are the symptoms of acute lead poisoning?

Metallic taste, thirst, colic, constipation, cramps, urinary suppression, convulsions, but the mind is preserved to the last.

Is the prognosis in acute lead poisoning favorable, and what is the treatment for it?

Prognosis in such cases is generally favorable; treatment should consist of emetics or stomach-pump followed by either magnesium or sodium sulphate and sulphuric acid lemonade to produce insoluble lead sulphate together with morphine for pain.

From what sources may chronic plumbism arise?

From drinking water or beer conducted through new leaden pipes, inhalation of, or absorption by the skin of white lead or paints, from snuff or chewing tobacco wrapped in lead, from lead-glazed pottery, from contact with lead or lead compounds as in plumbers, painters, lead workers, miners, type founders, also from cosmetics and hair restorers containing lead, and even from hat linings or biting off silk weighted with lead.

What are the symptoms of chronic plumbism?

Indigestion, colic and constipation, cachexia, ptyalism, weakness of muscles of forearm, lead palsy, wrist drop, paralysis of extensor muscles with atrophy of extensor and interosseous muscles; blue lines arising from deposit of PbS on the gums due to the presence of H_2S in the breath and decaying food; arthralgia, encephalopathy, spasms, mania, melancholia, convulsions, coma.

What is the treatment of chronic plumbism?

To clear out the alimentary tract with $MgSO_4$ or Na_2SO_4, also potassium iodide, tincture of iron, and galvanism.

How can lead compounds be recognized?

They give from acid solutions a black precipitate with H_2S, insoluble in acids, also with NH_4HS insoluble in excess. With sulphuric acid or soluble sulphates a white precipitate; with potassium iodide a yellow precipitate, also with potassium chromate.

How is urine or other liquids, suspected to contain lead, to be tested?

Concentrate to dryness and incinerate; dissolve residue in HNO_3 and evaporate solution to dryness over a water bath, dissolve in distilled water and test with H_2S. The sulphide, if sufficient, may then be reduced by the blow-pipe to a malleable particle of lead, or it may be dissolved in HNO_3, the acid evaporated and residue dissolved in distilled water to be tested with KI, when the lead iodide, after heating, will be seen under the microscope as six-sided plates.

Copper Group.

Of what metals does this group consist?

Copper, mercury, and silver.

Copper.

What is copper?

A reddish-brown metal Cu, a. w. 63.2, soft and ductile, sp. gr. 8.9, unaltered in dry air, with moisture it is coated with green copper carbonate; on heating it oxidizes to black cupric oxide. Dilute HCl or H_2SO_4 does not act on it, but the stronger acids dissolve it to form salts.

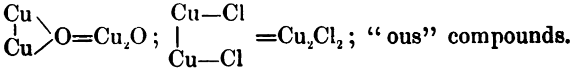
Which are the principal alloys of copper?

Brass $=Cu+Zn$; bronze Sn or Pb or $Zn+Cu$; bell metal $Sn+Cu$; German silver $Cu+Zn+Ni$.

What two classes of compounds does copper form?

Cupric and cuprous; monatomic in the cupric and diatomic in its "ous" compounds; the molecules of the latter, however, are to be regarded as double formulas.

Thus $Cu{=}O, Cu{=}Cl_2, Cu{=}(OH)_2, Cu{=}SO_4$; "ic" compounds.



$$\left.\begin{matrix}Cu\\|\\Cu\end{matrix}\right>O=Cu_2O;\quad \begin{matrix}Cu-Cl\\|\\Cu-Cl\end{matrix}=Cu_2Cl_2;\ \text{"ous" compounds.}$$

What is cupric hydrate, and how derived?

A greenish-blue precipitate resulting when a solution of a copper salt is treated with sodium or potassium hydrate. $Cu(OH)_2$. It readily changes into black cupric oxide when heated. $Cu(OH)_2=CuO+H_2O$.

What is cupric oxide?

A black amorphous powder CuO, forming when $Cu(OH)_2$ is heated as above, also by oxidation of copper turnings in the air. By heating it reduces carbon compounds forming carbon dioxide and water of them. It dissolves in the alkaline hydrates with a dark blue color, directly with NH_4OH, and in the presence of organic substances with KOH or NaOH. In the presence of glucose it is reduced at the boiling point to Cu_2O.

What is cuprous oxide?

A bright and crystalline powder Cu_2O, forming when a solution of CuO in NaOH or KOH is boiled in the presence of grape sugar.

Which are two chlorides of copper?

Cupric chloride $CuCl_2$ and cuprous chloride Cu_2Cl_2. The latter dissolved in NH_4HO has the property of absorbing carbon monoxide, and is used for the analysis of that gas.

What precipitate does H_2S yield with copper solutions?

A brownish-black precipitate of copper sulphide CuS.

Describe the sulphuric acid compound of copper.

Copper sulphate or sulphate of copper, also blue vitriol or bluestone $CuSO_4 + 5Aq$, is formed by the action of strong H_2SO_4 on copper. It is a blue crystalline efflorescent salt, giving off its water of crystallization on heating, and appears then as a white powder. $CuSO_4$ is an emetic, principally used in phosphorus poisoning.

What compound results when a solution of $CuSO_4$ is treated with NH_4OH?

A greenish-white precipitate is at first thrown down, which dissolves in an excess of the NH_4OH with a deep-blue color. This solution is known as the solution of ammonio-sulphate of copper, and a dry salt of that name is also officinal.

What is copper nitrate?

Cupric nitrate $Cu(NO_3)_2$; a crystalline salt, of dark-blue color, readily soluble in alcohol and water, and decomposed by heat into cupric oxide.

Describe the compounds of copper with arsenic.

Copper arsenite $Cu(AsO_3)_2$, also called Scheele's green, is a bright-green powder, precipitated by treating copper solutions with sodium or potassium arsenite. Schweinfurth or Paris green is an insoluble green crystalline powder, representing a mixture of acetate and arsenite of copper; both of these compounds are extremely poisonous, and the latter especially is used extensively for destroying insects on plants (potato bugs, etc.).

Which is the principal carbonate of copper?

The greenish-blue precipitate resulting when a solution of copper is treated with an alkaline carbonate; it is a basic carbonate of copper, $CuCO_3Cu(OH)_2$, also occurring in nature as malachite of a beautiful green color.

What are the two acetates of copper?

Cupric acetate or diacetate $Cu(C_2H_3O_2)_2 + Aq$; large bluish-green crystals, and acetate of copper, cupri subacetas U. S., also called verdigris or ærugo, consisting of a mixture of three different basic acetates of copper, which occur in masses of pale-green or bluish color.

What are the poisonous properties of copper?

Pure copper is non-poisonous, but the commercial variety is rarely free from arsenic. Pure copper should not stain if boiled in HCl; copper vessels are often soldered with Pb and Sn, and these may prove poisonous. Food decaying in copper vessels often generates poisonous ptomaines. Copper is probably dissolved by food from all copper vessels, but this is so little that it does no harm, but if the vessels corrode, and the food takes up the compounds, poisonous symptoms may arise.

What are the symptoms of poisoning by copper compounds?

Vomiting and metallic taste of vomit; color, resembling that of bilious vomit, greenish; turning blue on addition of HN_4OH; purging, tenesmus, colic pains, suppression of urine, and jaundice.

What are the antidotes for acute copper poisoning?

Iron by hydrogen, eggs, and demulcents.

Describe the symptoms of chronic copper poisoning.

These are frequently met with in malachite and copper workers; they exhibit a green line on the gums, lassitude, debility, tenesmus, and diarrhœa.

Which articles of food may give rise to copper poisoning?

Pickles, peas, and string-beans are sometimes colored with copper salts. Dentist's gold mixed with it may cause it, also spoiled flour corrected with Cu compounds, and jellies, sweetmeats, preserves, and fats left standing in copper vessels.

How may copper compounds be recognized?

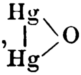
Metallic iron, such as needles or knives, dipped into articles containing copper compounds, become covered with metallic copper; H_2S gives with Cu solutions black precipitate, also ammonium sulphydrate, NH_4OH in excess strikes a deep blue color, and potassium ferrocyanide a brown precipitate.

Mercury.

What are mercury and its properties?

A bright metallic liquid Hg, a. w. 200, sp. gr. 13.6; volatile at all temperatures; boils at 360° C.; forms alloys with almost all metals; remains unaltered in the air, but oxidizes at or near its boiling-point.

What two classes of compounds does Hg form?

Like copper it forms "ous" and "ic" compounds, being monatomic in the "ic" and diatomic in the "ous" compounds, the molecules of the latter however seem to be regarded as double formulas. Thus: $Hg = O$ mercuric oxide,  $\begin{array}{c}Hg\\ |\\ Hg\end{array}\!\!>\!O$ mercurous oxide.

Is Hg as metal poisonous, and to what do its galenical preparations owe their activity?

In its metallic state it may be said to be non-poisonous, immense quantities having been ingested without disadvantage, and its preparations are more active on account of the mercurous oxide being present in them.

Which are the officinal preparations of metallic mercury?

Hydrarg. cum creta 38 per cent.; massa hydrarg., blue mass, 33 per cent.; unguent. hydrarg., blue ointment, 45 per cent.

What is the difference in action of the "ous" and "ic" compounds of Hg.?

The "ous" compounds are mild in action, and the "ic" compounds are violent and poisonous.

Which are the two oxides of mercury?

The mercurous or black oxide, Hg_2O, and the mercuric or red, also binoxide, HgO.

What are the properties of mercurous oxide, and how formed?

It is a brownish-black powder, gradually changing to HgO and Hg. It forms when a mercurous nitrate or chloride is treated with KOH or $NaOH$. It also forms when mercurous chloride (calomel) is treated with lime-water, $Ca(OH)_2$, and then forms the lotio nigra.

Which are the two kinds of mercuric oxide, and how formed?

HgO occurs either in a crystalline or amorphous state; the former being the so-called red precipitate or hydrargyri oxidum rubrum; the latter the yellow oxide, also called hydrargyri oxidum flavum; they are chemically identical, the red oxide being obtained by calcination of the mercuric nitrate; the latter by precipitating the mercuric chloride with KOH or $NaOH$, or also with $Ca(OH)_2$, when it forms the lotio flava.

Which are the two chlorides of mercury?

Mercurous chloride or mild chloride of mercury, also calomel, Hg_2Cl_2, and mercuric chloride, or corrosive sublimate $HgCl_2$.

What are the properties of mercurous chloride?

Calomel, as ordinarily met with, is a white amorphous powder, which sublimes without fusing, insoluble in water and alcohol; it is partly decomposed by the action of light into $HgCl_2$ and Hg; alkaline hydrates and carbonates decompose it into mercurous oxide; with NH_4OH it gives a black precipitate; it is not poisonous when pure and exhibited in ordinary doses, and may be given even in large doses with impunity; together with HCl or gastric juice or nitro-hydrochloric acid it may be converted into $HgCl_2$.

Give some of the reactions illustrating the incompatibilities of calomel.

$Hg_2Cl_2 = Hg + HgCl_2$; $Hg_2Cl_2 + Cl_2 = 2HgCl_2$;
$Hg_2Cl_2 + 2I = HgCl_2 + HgI_2$; $Hg_2Cl_2 + 2KI = 2KCl + Hg_2I_2$.

Hg_2Cl_2 with the hydrates or carbonates of K or Na react as follows:—

$Hg_2Cl_2 + Na_2CO_3 = Hg_2O + CO_2 + 2NaCl$;
Hg_2O splits up into $HgO + Hg$.

How can the varying effects of calomel be explained?

By the different reactions of the substances it meets with in the course of digestion.

What are the properties of mercuric chloride?

Corrosive sublimate is a crystalline compound, occurring in rectangular octahedra, crystallizing from water in fine rhombic prisms ; soluble in 15 parts water at ordinary temperature, sp. gr. 5.4, fuses at 288° C., and boils at 300° C. Alcohol dissolves about 30 per cent. of its weight, and ether 35 per cent. at ordinary temperature. It gives a white precipitate with NH_4OH ; with albumen it forms a white precipitate, soluble in an excess of albumen and alkaline chlorides ; it proves in this manner a corrosive poison, and is used principally as an antiseptic, which property it exhibits even in solutions of 1 to 40,000.

What is the precipitate of NH_4OH with $HgCl_2$?

White precipitate or ammoniated mercury, also mercur-ammonium chloride, NH_2HgCl, used in the unguentum hydrargyri ammoniati containing 10 per cent. of the NH_2HgCl.

Which are the two iodides of mercury?

Mercurous iodide, also green or protoiodide of mercury Hg_2I_2, a greenish-yellow amorphous powder insoluble in water and alcohol, and mercuric iodide or biniodide, also red iodide of mercury, HgI_2, a bright red precipitate resulting when a mercuric salt is treated, without excess, by potassium iodide ; it dissolves readily in a solution of KI forming iodohydrargyrate of potassium ; this is used in the mixed treatment of syphilis, also as an antiseptic and as a local irritant.

What is cyanide of mercury?

Hydrargyri cyanidum U. S., Hg $(CN)_2$, a crystalline compound, soluble in water and alcohol and very poisonous.

Which are the sulphides of mercury?

Mercurous sulphide Hg_2S formed by the action of H_2S on mercurous compounds, and mercuric sulphide occurring in nature as cinnabar or vermilion HgS. It is also obtained by heating the black sulphide precipitated from mercuric salts by H_2S.

Describe the two sulphates of mercury.

Mercurous sulphate Hg_2SO_4, a crystalline precipitate used in the manufacture of calomel, and mercuric sulphate $HgSO_4$, a white crystalline mass used in the manufacture of corrosive sublimate; subsulphate of mercury or turpeth mineral, a yellow insoluble basic salt; $HgSO_42HgO$, used as an emetic in group.

Which are the principal nitrates of mercury?

Mercurous nitrate, $Hg_2(NO_3)_2$, a crystalline compound formed by the action of HNO_3 with Hg in excess; and mercuric nitrate, $Hg(NO_3)_2$, formed by the action of HNO_3 in excess upon Hg; the solution of this latter is contained in the liquor hydrargyri nitratis or acid nitrate of mercury, and also in the unguentum hydrargyri nitratis or citrine ointment.

Give the toxic doses, medical use, and poisonous properties of $HgCl_2$.

The minimum fatal dose is about 3 grains, but recovery has taken place even after 80 grains; it may prove fatal in from a half hour to two weeks. It is largely used as an antiseptic, alterative, and parasiticide, also locally to remove freckles, etc.; in poisonous doses it acts as a corrosive, causing great pain in throat, bloody stools, slowing of pulse, tympani, bloody and mucous vomit, great thirst, suppression of urine, and collapse.

What is the antidote for acute poisoning by $HgCl_2$?

Eggs (1 egg can neutralize 4 grains), flour paste, mixture of iron filings and gold dust by galvanic action.

How can chronic poisoning by Hg be produced, and what are the symptoms of it?

By the vapors of Hg in looking-glass factories, by long continued medication with mercury compounds; producing salivation, tremor, debility, anæmia and fetid breadth, reddened and inflamed gums and ulceration thereof.

How can the ptyalism of Hg be distinguished from that of other poisons?

It gives rise to redness and inflamed gums which the others do not, and, besides, the Hg can be demonstrated in the saliva.

What is the treatment for chronic mercurialism?

Potassium iodide cautiously administered, also tonics, liberal diet, etc.

What are the different analytical reactions between mercurous and mercuric chlorides?

Mercurous gives a black precipitate with H_2S, turns black with $Ca(OH)_2$ forming Hg_2O, KOH turns it black, also NH_4OH; with KI greenish-yellow precipitate of Hg_2I_2. Mercuric chloride gives with H_2S, slowly introduced, a whitish precipitate at first, turning dark and reddish-brown when heated; with $Ca(OH)_2$ a yellow precipitate; with KOH a yellow precipitate; with NH_4OH a white precipitate; with KI a yellowish-red precipitate, soluble in excess of KI.

Which are the parts to be tested in suspected Hg poisoning, and how are they to be treated?

The saliva and urine are to be tested by Reinsch's test, the copper slips of which, on heating, deposit microscopical globules of Hg on reduction tube. Contents of stomach and vomit should be boiled with HCl, the result mixed with alcohol and the evaporated residue to be treated with ether, the residue of which is then tested by Reinsch's test, and the resulting globules of mercury in the reduction tube heated with a small crystal of iodine when bright red HgI_2 will form.

Silver.

What is silver and its properties?

A white brilliant metal, Ag, a. w. 10, sp. gr. 10.5. It is soft and ductile, fuses at 954° C., it does not combine with O directly but with the halogens; exposed to air containing HS_2 it turns black; it dissolves in HNO_3 and H_2SO_4 to form salts; it forms alloys with many metals, notably copper, which is of great hardness.

How many oxides does silver form, and which is the principal one?

It forms three oxides of which the monoxide Ag_2O is the principal one. It is prepared by precipitating silver nitrate solutions with KOH or NaOH, as a dark brown amorphous powder soluble in NH_4OH, with which it forms a highly explosive compound—fulminating silver.

What is silver chloride?

AgCl, a white curdy precipitate forming when a chloride or hydrochloric acid is added to a silver solution; exposed to light it turns dark and is readily soluble in NH_4OH.

What is the principal salt of silver in use in medicine?

Silver nitrate, $AgNO_3$, crystallizing in colorless right rhombic plates, soluble in equal parts of water; it turns black when contaminated with organic matter, fuses readily, and can be cast in moulds, the cylinders or sticks resulting are termed lunar caustic, and are used as an application to ulcers and wounds.

What is the precipitate resulting from the action of H_2S on solutions of silver?

Ag_2S, a black amorphous powder, insoluble in NH_4OH.

What is the poisonous action of $AgNO_3$ and antidote?

When swallowed it acts principally as a corrosive poison; when compounds of silver are taken internally for some time blue indelible coloration of the skin is apt to take place. When poisonous doses of $AgNO_3$ are taken sodium chloride and raw eggs should be freely and promptly administered.

How are compounds of silver recognized?

HCl or soluble chlorides give with their solutions a white curdy precipitate insoluble in HNO_3, soluble in NH_4OH; KOH and NaOH give brownish precipitates insoluble in excess, soluble in NH_4OH. Ammonium hydrate, brownish precipitate soluble in excess. Hydrogen sulphide or NH_4HS gives black precipitates.

Aluminium Group.

Of which metals does this group consist?

Aluminium, indium, gallium.

What are the characteristics of the metals of this group?

They are trivalents, form oxides which are weak bases, and their sulphates unite with those of the alkali metals to form double salts known as alums.

Aluminium.

What is aluminium?

A silver-white metal, Al, a. w. 27, very light, sp. gr. 2.58, very ductile; it does not tarnish in the air; is not acted on by HNO_3 and by H_2SO_4 only on boiling, but is readily soluble in HCl, and in KOH and NaOH giving off H; it is used largely as an alloy with copper, termed aluminium bronze.

Where and how does aluminium occur in nature?

Its compounds are widely distributed in nature, the oxide crystallizing as ruby, sapphire, corundum, and as emery. Most commonly it is found as silicate in clay, feldspar, mud, and cryolite.

What is the normal hydrate, and what the oxide of aluminium?

The normal hydrate $Al(OH)_3$ is the amorphous gelatinous precipitate resulting when the solution of an aluminium salt is precipitated with ammonium hydrate or carbonate. By calcining this, aluminium oxide, alumina, Al_2O_3, is obtained; this is a white amorphous, odorless, tasteless powder, only slightly acted on by acids and alkalies.

What are alums?

The double sulphates of aluminium and an alkali metal +12 Aq.

What other compounds besides these are termed alums?

The double sulphates of chromium, iron, or manganese, and an alkali metal +12Aq.

Which is the alum of the Pharmacopœia?

Potassium alum $AlK(SO_4)_2+12Aq$, crystallizing from water in large transparent octahedra, soluble in 8 parts of water, with acid reaction and sweetish styptic taste; it loses its water of crystallization on calcining and is then called burnt alum.

What alum was formerly in use, and officinal?

Ammonium alum $AlNH_4(SO_4)_2+12Aq$.

Name some of the other so-called alums and give their formulas.

Potassium iron alum $FeK(SO_4)_2+12Aq$.
Ammonio chromium alum $CrNH_4(SO_4)_2+12Aq$.
Sodium manganese alum $MnNa(SO_4)_2+12Aq$.

How may the compounds of aluminium be recognized?

White gelatinous precipitate with KOH or NaOH, soluble in excess; NH_4 also causes a similar precipitate but it is not soluble in excess of reagent; alkaline carbonates precipitate the hydrate with escape of CO_2.

Iron Group.

Of which metals does this group consist?

Manganese, iron, cobalt, and nickel.

Manganese.

What are the three series of compounds formed by manganese, and what is its valences in them?

Manganous compounds in which it is a divalent; manganic compounds in which it is tetravalent; manganic acid derivatives in which it is hexavalent.

Which is the principal oxide of manganese?

Manganese dioxide or peroxide, also termed black oxide of manganese MnO_2, found in crystalline black masses; it is decomposed by hot HCl liberating Cl, and by H_2SO_4 liberating O, forming manganous sulphate, a rose-colored crystalline salt $MnSO_4$.

What is potassium permanganate?

A dark-red crystalline compound $KMnO_4$, soluble in 12 parts of water, with a beautiful, deep-purple color, readily decomposed by organic matter, to which it gives off oxygen, thereby destroying it, rendering it a powerful disinfectant.

When manganese compounds are treated with ammonium sulphydrate what results?

A flesh-colored precipitate of manganous sulphide MnS.

Iron.

What is iron?

Iron, ferrum, Fe, a. w. 56, is, when pure, a metal of a grayish-white color, sp. gr. 7.78; in moist air it is gradually covered with iron rust, ferric hydrate; by heating in the air it is coated with ferrous-ferric oxide Fe_3O_4; at red heat it decomposes water, liberating H; it unites with the halogens and also sulphur, and dissolves in HCl and H_2SO_4 to form ferrous compounds while liberating H; it forms two classes of compounds, the ferrous and ferric; in the former it is divalent and monatomic, and diatomic and tetravalent in the latter; while still a higher oxide corresponds to the manganic acid derivatives and its hexavalent.

What different varieties of iron are there?

Three different varieties, owing to the amount of carbon contained in it. Thus cast-iron, containing 3 to 6 per cent. C., is very hard and brittle; steel 0.8 to 1.8 per cent. C., and wrought-iron, which has only about 0.2 to 0.6 per cent. C., is quite ductile.

What form of metallic iron is officinal, and how is it prepared?

The ferrum reductum, or iron by hydrogen, also Quevenne's iron ; it is prepared by passing a current of hydrogen over ferric oxide at red heat, when the Fe_2O_3 is reduced to Fe.

$$Fe_2O_3 + 3H_2 = 2Fe + 3H_2O.$$

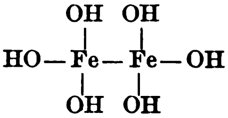
What is ferrous and what ferric hydrate, and how formed?

$Fe(OH)_2$ is formed when a ferrous compound is treated with an alkaline hydrate, $FeSo_4 + 2NH_4OH = Fe(OH)_2 + (NH_4)_2SO_4$; it is a whitish-green precipitate, rapidly changing to muddy-green and reddish-brown. Ferric hydrate $Fe_2(OH)_6$ results when a ferric compound is treated with an alkaline hydrate, $Fe_2Cl_6 + 6NH_4OH = Fe_2(OH)_6 + 6NH_4Cl$; a reddish-brown precipitate, which gradually changes to form oxyhydrate $Fe_2O(OH)_4$.

By what formulas can the monatomic and diatomic character of respectively ferrous hydrate and ferric hydrate be illustrated?

$$HO - Fe - OH$$

Monatomic divalent.



$$\begin{array}{ccccccc} & & OH & & OH & & \\ & & | & & | & & \\ HO & - & Fe & - & Fe & - & OH \\ & & | & & | & & \\ & & OH & & OH & & \end{array}$$

Diatomic tetravalent.

Give some of the synonyms of ferric hydrate, and its principal use in medicine.

Ferri oxidum hydratum U. S., hydrated oxide of iron, also hydrated sesquioxide of iron, principally used as an antidote for poisoning by arsenic, also in the manufacture of dialyzed iron.

How is ferric hydrate prepared for use as an antidote?

Precipitate ferric chloride or ferric sulphate solution with NH_4OH; separate the moist precipitate on a strainer, wash well with water until all ammonia odor has disappeared, and then administer in tablespoonfuls. As it changes to the inert oxyhydrate on standing, it should always be prepared fresh as needed.

By what process is this antidote for arsenic still better and more promptly made?

By precipitating the ferric chloride or sulphate solutions with magnesia : $Fe_2(SO_4)_3 + 3MgO + 3H_2O = 3MgSO_4 + Fe_2(OH)_6$; this needs no straining or washing, and an excess of magnesia will prove rather of advantage than otherwise.

How may this be kept on hand for use in emergencies?

The ferric solution and the magnesia in different bottles, as follows:—

℞. Liq. ferri tersulphatis, f℥ij;
Aquæ, f℥vi.
M. S. *A.*

℞. Magnesiæ, gr. cl;
Aquæ, f℥viij.
M. S. *B.*

Keep *A* and *B* separate until needed, when they are simply mixed to be ready for use.

Illustrate the reaction by which $Fe_2(OH)_6$ acts as an antidote for arsenic.

$$2(Fe_2(OH)_6) + As_2O_3 = Fe_3 2AsO_4 + 5H_2O + Fe(OH)_2;$$

i. e., the ferric hydrate changes the arsenic into the inert ferrous arsenate.

What is dialyzed iron?

Ferric hydrate dissolved in a solution of ferric chloride to saturation, and deprived of free acid and crystalloids by dialysis.

What is the value of dialyzed iron medicinally and as an antidote for arsenic?

It is not now considered as of much value, if of any, therapeutically, but is claimed as a good antidote for arsenic.

What is dialysis?

The process of separating crystalloids and colloids by osmosis through a colloid septum, such as animal membranes or parchment paper.

Define the meaning of diffusate, dialysate, crystalloids, and colloids.

A diffusate is the substance capable of passing through the dialyzing membrane; a dialysate that which in the same process does not pass through; crystalloids are bodies capable of assuming regular or crystalline form, and colloids such as assume only irregular or globular form.

Which are the principal oxides of iron?

Ferrous oxide FeO; Ferric oxide Fe_2O_3, the colgothar or caput mortuum, residue in the manufacture of Nordhausen sulphuric acid from ferrous sulphate; ferrous-ferric oxide or magnetic oxide of iron Fe_3O_4.

Describe the two chlorides of iron.

Ferrous chloride $FeCl_2$, a green deliquescent crystalline compound, forming by the action of HCl on metallic iron; ferric chloride, also termed sesquichloride or perchloride of iron $Fe_2Cl_6 + 6Aq$, remaining on evaporation of the solution in yellow crystalline masses, soluble in water, alcohol, and ether.

What is the officinal solution and tincture of ferric chloride?

Liquor ferri chloridi U. S. is a solution containing 31.8 per cent. Fe_2Cl_6; prepared by dissolving Fe in an excess of HCl, adding HNO_3 while boiling, when Fe_2Cl_6 is formed; 35 parts of this with 65 parts of alcohol make the tinctura ferri chloridi U. S.

What is ferrous bromide, and what is its officinal preparation?

$FeBr_2$, a yellowish-green crystalline compound, entering the syrupus ferri bromidi U. S. which contains 10 per cent. of it.

What is ferrous iodide, and its officinal preparations?

FeI_2, prepared by the action of iodine on iron in excess. It enters the syrupus ferri iodidi U. S. to the extent of 10 per cent.; pilulæ ferri iodidi containing 1 grain each of FeI_2, with an excess of reduced iron.

What is ferrous sulphide, how prepared, and for what used?

A brownish-black mass, ferri sulphuretum U. S.; FeS is formed by fusing sulphur and iron filings in a red-hot crucible; it is used to prepare hydrogen sulphide, *q. v.*

Describe the ferri sulphas U. S.

It is ferrous sulphate, also termed copperas, or green vitriol $FeSo_4 + 7Aq$; a green crystalline salt, somewhat efflorescent;

loses its water of crystallization on heating, and then forms a white powder, known as dried sulphate of iron, or ferri sulphas exsiccatus.

Which are the principal ferric sulphates?

The normal sulphate $Fe_2(SO_4)_3$, 28.7 per cent. in the liquor ferri tersulphatis U. S., and the basic ferric sulphate $Fe_4O(SO_4)_5$, 43.7 per cent. of which is contained in the liquor ferri subsulphatis U. S., Monsell's solution. Both of the officinal solutions are reddish-brown.

What is liquor ferri nitratis U. S.?

A solution containing about 6 per cent. of the ferric nitrate $Fe_2(NO_3)_6$.

What is ferrous phosphate, and what the ferri phosphas U. S.?

Ferrous phosphate $Fe_3(PO_4)_2$ resulting when ferrous sulphate is precipitated with di-sodium phosphate; it is a powder, white at first, but rapidly turning blue. The ferri phosphas U. S. is a sodio-ferric-citro-phosphate, in thin bright green scales.

Which carbonate of iron is used in medicine, and in what form?

The ferrous carbonate $FeCO_3$ resulting from the decomposition of ferrous sulphate with an alkaline carbonate; it is a whitish-green precipitate turning brown owing to the formation of ferric hydrate, which is prevented by the addition of sugar. The officinal preparations are ferri carbonas saccharatus, a grayish-green powder, massa ferri carbonatis or Valett's mass, containing about 42 per cent. $FeCO_3$.

What is Prussian blue?

Ferric ferrocyanide; ferri ferrocyanidum U. S., $(Fe_2)_2(FeC_6N_6)_3+18Aq$, a dark blue precipitate resulting from potassium ferrocyanide and a ferric salt.

How can the compounds of iron be recognized?

Ferrous of white or greenish color; alkaline hydrates, greenish-white precipitates; ammonium sulphydrate, black precipitate soluble in acids; potassium ferrocyanide, greenish-white precipitate; potassium ferricyanide, blue precipitate (Turnbull's blue).

[illegible] brown color: alkaline hydrates, heavy [illegible] ammonium sulphydrate, black precipitate [illegible] potassium ferrocyanide, dark blue precipi- [illegible] potassium sulphocyanide, dark red color; [illegible] the ferric salts are for this reason [illegible] vegetable astringents.

Nickel.

What is nickel?

[illegible] of great lustre and very [illegible] does not tarnish in the air: it is used [illegible] of steel and iron instruments to [illegible] takes on a high polish when so used.

What compound of nickel is used sometimes in medicine?

[illegible] which is often made [illegible] dark green color.

Chromium Group.

What is the member of this group of interest in medicine?

[illegible] forming two series of compounds [illegible] chromic acid derivatives: it forms [illegible] the alkali metals, termed chromium [illegible]

What are the principal oxides of chromium?

[illegible] green amorphous powder, and chromium [illegible]

What are the properties of chromic acid anhydride?

[illegible] chromic acid [illegible] tissues, is very de- [illegible] oxidizing [illegible]

What is the potassium salt corresponding to chromic acid?

[illegible] yellow potassium [illegible] as an indicator in the determination of [illegible]

What is potassium dichromate?

Bichromate of potassium or acid potassium chromate, also termed red potassium chromate, $K_2Cr_2O_7$, corresponding to a non-isolated acid of the formula $H_2Cr_2O_7$, analogous in its composition to fuming sulphuric acid ($H_2S_2O_7$), largely employed in battery fluid, *q. v.*

What is the action of the chromates on the economy?

They are irritant and corrosive poisons; K_2CrO_4 is sometimes used in the treatment of syphilis. The chromates act also as local irritants, producing in workmen engaged with them chronic ulcers and ozœna resembling those of arsenic; they often aggravate syphilitic sores.

What is the treatment for, and the analytical characters of the chromates?

Removal of cause, potassium iodide; they give no precipitate with H_2S but a green precipitate with NH_4HS; with lead salts they produce yellow lead chromate.

Uranium.

Symb. U, a. w. 240.

What are the principal salts of uranium used in medicine?

Uranium nitrate or uranyl nitrate, $UO_2(NO_3)_2$, large greenish-yellow prisms used sometimes in the treatment of diabetes mellitus. Uranium acetate $UrO_2(C_2H_3O_2)_2$ used for the titration of phosphoric acid.

Tin Group.

What is the most important metal of this group?

Tin, stannum, Sn, a. w. 117.8, a silvery-white metal, sp. gr. 7.3, of crystalline structure, soft and ductile, fusing at 228° C., and distilling at white heat. It does not oxidize on exposure, forms a number of useful and interesting alloys, and two series of compounds, stannous and stannic; it is a dyad in the former and a tetrad in the latter.

Which are the oxides of Sn?

Stannous oxide, SnO, a brownish-black powder which burns, when heated in the air, to stannic oxide; putty powder, SnO_2, a white amorphous powder, insoluble and infusible, but yielding stannates when fused with the hydrates of potassium or sodium.

What is stannous chloride?

A crystalline compound, $SnCl_2 2+Aq$, resulting from the action of HCl on metallic tin. It is used as mordant in dyeing, under the name of tin salt, and as a reducing agent.

What is stannic chloride?

A colorless liquid, $SnCl_4$, fuming in the air, sp. gr. 2.27, boiling at 114° C.

What precipitates result respectively from stannous and stannic compounds with H_2S?

Stannous give brown stannous sulphide, SnS. Stannic give yellow stannic sulphide, SnS_2.

Is tin poisonous and how do its soluble compounds act? Antidotes?

Metallic tin is non-poisonous but its soluble compounds are irritant poisons. Antidotes: ammonium carbonate, milk, and eggs.

How may stannous and stannic compounds be recognized?

Stannous give brown precipitate with H_2S; with mercuric chloride gray precipitate of Hg; with gold chloride a purple precipitate. Stannic give yellow precipitate with H_2S; with KOH or NaOH white precipitate soluble in excess, also with ammonium hydrate or carbonate, slightly soluble in excess.

Bismuth Group.

What is the principal member of this group, and what group should it really belong to?

Bismuth. It should be classed with the nitrogen group, but it does not form a hydrogen compound like the other members.

What is bismuth?

A reddish-white metal, Bi, a. w. 207, sp. gr. 9.9, crystalline, fusing at 267° C., and distilling at white heat. Like members of the nitrogen group it forms two oxides Bi_2O_3 and Bi_2O_5, and is therefore triad and pentad ; it is readily acted on by HNO_3, and its soluble salts are converted by water into insoluble basic salts.

Which are its principal halogen compounds?

Bismuth chloride, $BiCl_3$, forming with water a white crystalline precipitate of bismuth oxychloride, BiOCl ; bismuth bromide, $BiBr_3$ and BiI_3 are analogous compounds ; bismuth subiodide, BiOI, is a red amorphous powder used as a surgical dressing.

What results if soluble compounds or salts of Bi are diluted with water?

Oxycompounds or oxysalts result containing the group $(BiO)^I$ which is by some regarded as a radical and termed bismuthyl.

Which is the principal oxide of bismuth?

The trioxide, Bi_2O_3, formed by the oxidation of metallic bismuth by burning it in air.

What results if an oxysalt of bismuth is treated with KOH or NaOH?

A metahydrate, BiO(OH), is formed.

What changes does BiO(OH) undergo on boiling?

It changes to bismuth trioxide, Bi_2O_3.

$$2BiO(OH)=Bi_2O_3+H_2O.$$

Which test depends on this?

The alkaline bismuth or Boettger's test for glucose ; it depends on forming first a bismuth metahydrate, $BiONO_3+KOH =BiO(OH)+KNO_3$, the BiO(OH) becoming Bi_2O_3 in turn, which is deoxidized by glucose and metallic bismuth results.

How is Boettger's test for glucose performed?

Put in a test tube equal volumes of suspected urine and KOH with a pinch of bismuth subnitrate ; on boiling, if glucose is present, the white powder turns gray, brown, or black from reduction to metallic bismuth.

Which are the fallacies of this test, and how detected?

Albumin and sulphur compounds in the urine may cause a black precipitate of bismuth sulphide, Bi_2S_3. To detect them make the test, using a little litharge instead of the bismuth salt; if this blackens, the test is not available.

Which are the two bismuth nitrates?

Bismuth nitrate, $Bi(NO_3)_3$, a crystalline salt formed by the action of HNO_3 on bismuth. Bismuth subnitrate, $BiONO_3$, usually of varying and indefinite composition, is a white powder consisting of microscopical crystals formed by precipitating $Bi(NO_3)_3$ with water.

What is bismuth generally contaminated with?

With arsenic in greater or less proportion.

What is bismuth subcarbonas U. S.?

A white precipitate, $(BiO)_2CO_3$, forming when a soluble salt of bismuth is precipitated by an alkaline carbonate.

How may bismuth compounds and salts be recognized?

Solutions give a white precipitate with alkaline hydrates insoluble in excess, turning yellow on boiling; H_2S, and NH_4HS give black precipitates of Bi_2S_3; largely diluted with water solutions give rise to precipitates of basic salts soluble in HNO_3.

Platinum Group.

Which are the most notable members of this group?

Gold and platinum.

Gold.

What is gold?

Gold, aurum, Au, a. w. 196, is a soft yellow metal, sp. gr. 19.32, very ductile, melts at 1035° C. to a greenish liquid; is not acted on by oxygen directly nor by the acids, excepting nitro-hydrochloric acid; it forms various alloys harder than the pure metal.

What are the chlorides of gold?

The aurous chloride, $AuCl$; and the auric chloride, $AuCl_3$, resulting on solution of gold in aqua regia. The auric chloride forms double salts with the alkaline chlorides, such as $AuCl_3KCl$, $AuCl_3NaCl$, $AuCl_3NH_4Cl$; some of these are used medicinally; $AuCl_3$ is used as a precipitant for alkaloids and ptomaines.

Platinum.

What is platinum?

A metal, Pt, a. w. 194, of grayish-white color, sp. gr. 21.4, very tough, malleable, and ductile. It melts only at intense heat, and is insoluble in all acids excepting aqua regia; it forms platinous and platinic derivatives.

Which is the principal compound of platinum?

Platinic chloride, $PtCl_4$, obtained by dissolving platinum in aqua regia; it is reddish-brown and very deliquescent, forms double chlorides with KCl and NH_4Cl, which are crystalline and very insoluble in water; on this account $PtCl_4$ is used as a reagent to detect potassium and ammonium compounds, and also as a precipitant for alkaloids and ptomaines.

Hydrocarbons and Derivatives.

Why was the chemistry of the carbon compounds formerly considered separately as organic chemistry?

Because it was thought that organic force played a material part in their development, and that the living organism alone was capable of producing them.

Is this so, and is organic chemistry based upon different principles from that of the so-called inorganic bodies?

No, for many organic products have been synthetically built up, and the chemical laws aoplying to other elements also apply to carbon.

Which compounds of carbon are the most numerous?

The compounds of carbon with hydrogen, termed hydrocarbons, and their derivatives.

What two classes may these be divided into?

Into the fatty and aromatic, according to the characters of their derivatives.

How else may they be subdivided?

Into saturated or paraffins, and into unsaturated hydrocarbons.

What are saturated hydrocarbons?

Hydrocarbons in which the affinities of the tetravalent carbon are singly satisfied, and which cannot form compounds except by substitution.

What are unsaturated hydrocarbons?

Those resulting when saturated hydrocarbons lose some of their hydrogens and the affinities of these go to the carbon atoms of each other. They can form direct addition compounds with other atoms or radicals.

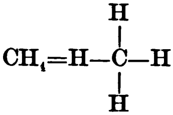
How are hydrocarbons grouped?

Into homologous series, *i. e.*, groups in which each member increases over the other by CH_2; if grouped so that they increase by H_2 the series are called isologous.

How are homologous series characterized?

By algebraic formulas giving the relative proportion of the number of carbon atoms to those of hydrogen combined with them as follows: C_nH_{2n+2} in which $_n$ expresses the number of atoms of each; thus if 2 were to stand for $_n$, C_nH_{2n+2} would be $C_2H_{2\times +2}=C_2H_6$.

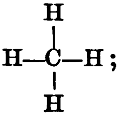
What is the simplest saturated hydrocarbon, and its graphical formula?



$$\text{Methane}\ CH_4=H-\overset{\displaystyle H}{\underset{\displaystyle H}{C}}-H$$

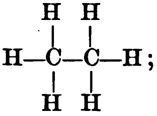
What is the carbon skeleton?

The graphical formula representing saturated hydrocarbons:



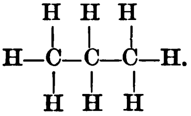
$$H-\overset{\displaystyle H}{\underset{\displaystyle H}{C}}-H;$$

CH_4



$$H-\overset{\displaystyle H}{\underset{\displaystyle H}{C}}-\overset{\displaystyle H}{\underset{\displaystyle H}{C}}-H;$$

C_2H_6



$$H-\overset{\displaystyle H}{\underset{\displaystyle H}{C}}-\overset{\displaystyle H}{\underset{\displaystyle H}{C}}-\overset{\displaystyle H}{\underset{\displaystyle H}{C}}-H.$$

C_3H_8.

How may saturated hydrocarbons also be regarded?

As hydrides of radicals, the latter having one free affinity with which they can combine with univalent atoms or radicals; thus $CH_4=CH_3H$; the radicals ending in "yl," as per example, methyl CH_3.

Which are the first six members of the methane series?

C_nH_{2n+2}		C_nH_{2n+1}
CH_4 Methane	radical	Methyl CH_3—
C_2H_6 Ethane	"	Ethyl C_2H_5—
C_3H_8 Propane or tritane	"	Propyl C_3H_7—
C_4H_{10} Butane or tetrane	"	Butyl C_4H_9–
C_5H_{12} Pentane	"	Amyl C_5H_{11}—
C_6H_{14} Hexane	"	Hexyl C_6H_{13}—

What is methane?

Marsh-gas, light, carburetted hydrogen or firedamp, is a light colorless, tasteless gas, sp. gr. 0.559, does not support combustion, but burns with a blue flame; mixed with air and ignited it explodes; it generates from decaying organic matter in swamps, also in mines and from coal and petroleum deposits; in mines it forms the firedamp; it is the principal ingredient in natural gas; it is also present in coal gas; pure methane may be prepared by heating NaOH and sodium acetate.

$$NaC_2H_3O_2+NaOH=Na_2CO_3+CH_4.$$

How is fire-damp detected in mines?

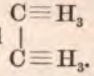
By the use of a Davy's safety lamp, which consists of a lamp perfectly closed with wire gauze; when the gas burns inside with blue flame fire-damp is present.

On what principle do they work?

The gauze cools off the flame, and by reducing its heat prevents its reaching the kindling point of the fire-damp.

What is ethane?

C_2H_6, the second member of the methane group; a colorless, odorless gas, which may be also considered as an ethyl hydride $C_2H_5 - H$, or dimethyl



$$\begin{array}{c} C\equiv H_3 \\ | \\ C\equiv H_3. \end{array}$$

How may ethane be prepared?

By the action of sodium on monochlormethane.

$$2CH_3Cl + 2Na = C_2H_6 + 2NaCl.$$

In what substance are many of the higher members of the methane series contained?

In petroleum, which is itself a complex body, composed of many other hydrocarbons of different boiling points and density.

Which are some of the well-known bodies isolated from petroleum?

Rhigolene, gasolin, benzin (petroleum ether), coal oil, lubricating oils, petroleum, and paraffin.

What is petrolatum?

Mixtures of paraffin and heavier petroleum oils, purified and of proper density; they are known variously as vaseline, cosmoline, etc., used largely as ointment bases.

What is paraffin?

A white solid hydrocarbon, used in the manufacture of candles, also for coating labels and stoppers to prevent them from the action of corrosive fluids.

Substitution compounds of hydrocarbons, what are they?

Compounds formed by replacing one or more of the hydrogens of a saturated hydrocarbon by elements or radicals.

Show the chlorine substitution in methane.

$CH_4+Cl_2=HCl+CH_3Cl$, monochlormethane.
$CH_3Cl+Cl_2=HCl+CH_2Cl_2$, dichlormethane.
$CH_2Cl_2+Cl_2=HCl+CHCl_3$, trichlormethane.
$CHCl_3+Cl_2=HCl+CCl_4$, tetrachlormethane or tetrachlorcarbon.

What are the substitution products of the halogens called?

Halogen substitution products, or haloid ethers.

What are the products of substitution in methanes also called?

Methyl compounds, as they may be viewed as compounds of the radical methyl with the substituting body.

What is brommethane or methyl bromide?

A clear mobile liquid, CH_3Br, made by the action of Br on methane, or better by HBr on methylic alcohol, CH_3OH; it has anæsthetic properties.

Iodomethane, what is it?

Methyl iodide, CH_3I, made similar to CH_3Br, but with iodine instead of Br.

What is dichlormethane?

Methyl dichloride, CH_2Cl_2; a colorless heavy liquid, resembling chloroform, also anæsthetic.

Trichlormethane, what is it?

Chloroform $CHCl_3$; a heavy mobile liquid.

What are all the chlorine substitution products of methane, and why of interest in medicine?

Because they are all anæsthetics.

Describe the physical properties of chloroform.

It is a heavy mobile fluid, of pleasant odor, non-inflammable, sp. gr. 1.497, and of a burning taste.

Name the two varieties of chloroform in the market, which alone should be used for anæsthesia, and state the test for the latter.

Chloroformum venale and chloroformum purificatum; the latter only should be used for anæsthesia; shaken with equal volumes of H_2SO_4, it should color it only slightly yellow.

How and when only should chloroform be administered as an anæsthetic?

With access of atmospheric air and due care, and after ascertaining absence of heart lesions.

What should be done if heart failure from chloroform ensues in anæsthesia?

Ammonia or whiskey, or both, should be injected; nitrite of amyl for inhalation; galvanism to cardiac region, and artificial respiration.

How does chloroform act locally and how internally in toxic doses; antidotes?

Locally, chloroform acts as a rubefacient, vesicant if confined, and slightly anæsthetic; internally, it sets up inflammation of the stomach; treated by oils, emetics, and stomach pump.

What is the tri-iodomethane, and how made?

Iodoform, CHI_3, formed by the action of KOH or NaOH in water on alcohol with iodine; it is used as a test for the presence of alcohol and will show $\frac{1}{3000}$ part of it.

State the physical and medicinal properties of iodoform.

It is a crystalline solid of yellow color and saffron-like odor; it contains 96.7 per cent. of iodine, possesses anæsthetic powers, especially locally on the anal sphincter; it is poisonous in over doses.

What is tri-brommethane?

Bromoform, $CHBr_3$, a colorless liquid, resembling chloroform.

What is chlorethane?

Ethyl chloride, C_2H_5Cl, an ethane in which one H is substituted by Cl.

What is bromethane?

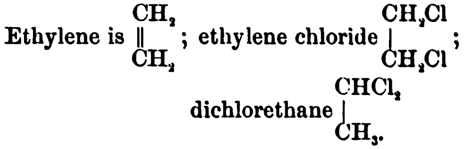
Ethyl bromide, C_2H_5Br, an ethane in which one H is substituted by Br; it is a colorless heavy liquid of ethereal odor, an anæsthetic of great value, but not less dangerous than chloroform.

What is iodoethane?

Ethyl iodide, C_2H_5I, a heavy liquid of ethereal odor, has anæsthetic properties, used for inhalation, and apt to grow darker on keeping by the liberation of iodine.

What is dichlorethane?

Dichlorethane is isomeric with ethylene chloride.



$$\text{Ethylene is } \begin{array}{c} CH_2 \\ \| \\ CH_2 \end{array}; \text{ ethylene chloride } \begin{array}{c} CH_2Cl \\ | \\ CH_2Cl \end{array};$$

$$\text{dichlorethane } \begin{array}{c} CHCl_2 \\ | \\ CH_3. \end{array}$$

Name the principal oxygen derivatives of the hydrocarbons.

Alcohols, ethers, aldehydes, and acids.

Alcohols.

What is an alcohol, and what different forms of alcohol are there?

Alcohols are hydrates of hydrocarbon radicals; according to the saturating power of the radicals there are monotomic, diatomic, and triatomic alcohols.

What is methylic alcohol?

Methyl hydrate, CH_3OH; wood spirits, pyroxylic spirit or wood naphtha, derived by dry distillation of wood; if mixed with 90 per cent. of ethylic alcohol it is known as methylated spirits, such as used in the arts, and is so contaminated in order to prevent its use for drinking purposes.

What are the properties of methylic alcohol?

It is a clear, colorless liquid if pure, boils at 66.7° C., burns and intoxicates, is poisonous when concentrated, and a solvent for fats, oils, resins, and is used for making varnishes, also to preserve specimens.

What is ethylic alcohol, and how obtained?

Ethyl hydrate, C_2H_5OH, spirit of wine, ordinary alcohol, obtained by distillation of fermented glucose or substances containing it.

How does glucose split up by fermentation?

It splits up into alcohol, C_2H_5OH, and carbon dioxide.

$$C_6H_{12}O_6 = 2C_2H_5OH + 2CO_2.$$

Fermentation, what is it?

Chemical action induced by ferments.

How may ferments be subdivided?

Into organized and soluble ferments.

What are organized ferments?

Minute bodies of organized existence capable of growth and reproduction; they can be separated by filtration.

Which organized ferment induces alcoholic fermentation?

The so-called brewers' yeast, termed torula or saccharomyces cerevisiæ.

Which are the unorganized or soluble ferments of the body?

Ferment bodies incapable of growth and reproduction, and readily passing through filters; they are the salivary, gastric, and pancreatic digestive ferments.

Explain the action of the salivary ferment.

Ptyalin, the ferment contained in saliva, converts starch into glucose.

$$\underset{\text{Starch.}}{2C_6H_{10}O_5} + H_2O = \underset{\text{Dextrin.}}{C_6H_{10}O_5} + \underset{\text{Glucose.}}{C_6H_{12}O_6}.$$

What is the action of the gastric ferment?

Pepsin, the gastric ferment, converts albumin into peptone, leucin, tyrosin, indol, etc.

How does the pancreatic ferment act on the fats?

Pancreatin splits up the neutral fats into fatty acids and glycerin.

$$\underset{\text{Suet (stearin.)}}{C_{15}H_{110}O_6} + 3H_2O = \underset{\text{Stearic acid.}}{3C_{18}H_{36}O_2} + \underset{\text{Glycerin.}}{C_3H_8O_3}$$

What is the first step in the process for the production of alcohol?

The conversion of starch by malt diastase (analogous to ptyalin) into glucose.

How can the complete conversion of starch into dextrin and glucose be proven?

When the wort, on addition of iodine, no longer gives rise to a blue color.

What is extract of malt, and what is its medicinal value?

An extract produced by condensing wort made from malt. Its value depends on the amount of glucose and dextrin it contains as nutrients, and on the presence of diastase as a ferment to aid in the digestion of carbohydrates.

Describe the second stage of the process for the manufacture of alcohol.

This consists of the fermentation of the wort by means of brewers' yeast.

Are other products besides alcohol and CO_2 results of fermentation of wort?

Yes; various others are caused by the presence and action of foreign ferments in the air; the vinegar ferment (mycoderma aceti) may also induce acetous fermentation of the alcohol, *i. e.*, produce vinegar (acetic acid) $C_2H_6O+O_2=C_2H_4O_2+H_2O$.

What fermentation would putrid cheese induce?

It would induce lactic fermentation, splitting up the glucose into lactic acid, of which it is a polymeric isomer.

$$\underset{\text{Glucose.}}{C_6H_{12}O_6} = \underset{\text{Lactic acid.}}{2C_3H_6O_3}$$

Is cane sugar subject to the same fermentative changes as glucose?

No, it has to be changed into glucose first.

What is butyric fermentation?

The splitting up of lactic acid under the influence of butyric ferment into butryic acid, carbon dioxide, and hydrogen.

$$\underset{\text{Lactic acid.}}{2C_3H_6O_3} = \underset{\text{Butyric acid.}}{C_4H_8O_2} + 2CO_2 + H_4$$

Describe the properties of alcohol.

It is a light, colorless liquid of characteristic odor and of burning taste, miscible in all proportions with water, the mixing being accompanied by elevation of temperature and contraction of volume. The alcohol of the U. S. P. has a sp. gr. 0.820, containing 94 per cent. of absolute alcohol by volume.

What does alcohol usually contain when first distilled, and how deprived of it?

It contains amylic alcohol (fusel oil), succinic acid, and glycerin, the former of which is removed by the absorptive power of charcoal.

By what test, and how can the presence of alcohol be established?

By Anstie's test, which consists of adding to the liquid to be tested a little potassium dichromate, $K_2Cr_2O_7$, and some sulphuric acid; on warming a beautiful emerald-green color will be developed if alcohol is present.

On what chemical changes does this test depend?

On the formation of chromic acid first, which, by the oxidation of the alcohol, is reduced to the emerald-green chromium oxide Cr_2O_3.

To what is the deleterious effect of young and poor whiskey due?

To the presence of fusel oil, amylic alcohol, $C_5H_{11}OH$, also called potato spirit, which in small quantities has a pleasant odor, but a suffocating one when strong. It rapidly produces intoxication, gastric disturbance, and headache.

Which are the principal alcoholic beverages, and what amount of alcohol do they contain?

Weiss beer 1 per cent., lager beer 2½ to 3½ per cent., ale and porter about 6 per cent; sweet wines contain undecomposed sugar; dry wines have all their sugar converted into alcohol; sparkling wines are fermented so as to retain the CO_2 in solution. Vinum album and vinum rubrum contain 10–12 per cent.; vinum rubrum fortior contains about 20 per cent., cider about 6 per cent.; brandy, whiskey, gin, and rum about 40–50 per cent.

Of what medicinal use are alcoholics?

They are diffusible stimulants, especially for the cardiac action.

How does alcohol act as a poison?

In acute poisoning the nerve action is paralyzed until the progressive influence reaches the medulla, when coma ensues; in chronic poisoning it causes thickening of the connective tissue, and thus catarrhal conditions of the mucous membranes and atrophy of the glands and organs, liver, kidneys, brittle condition of the bloodvessels, tremor and dulness, ending in paraplegia.

What is the treatment for alcoholic coma?

Stomach pump, faradism over the diaphragm, flagellation with wet cloths, cold affusion, and artificial respiration.

Ethers.

What are ethers?

Oxides of alcoholic radicals bearing the same relation to alcohols as oxides of bases to their hydrates. CH_3OH like KOH, $(CH_3)_2O$ like K_2O.

Give reaction if methylic or ethylic alcohols are treated with potassium.

The H of the OH of the alcohols is replaced, and the oxide of methyl or ethyl and potassium results.

$$CH_3OH+K=CH_3OK+H\ ;\ C_2H_5OH+K=C_2H_5OK+H.$$

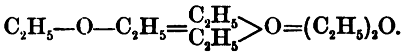
If, in this resulting oxide, the K is displaced by methyl or ethyl iodide, what forms?

The methyl or ethyl takes the place of the K, and ether is formed.

$$C_2H_5OK + C_2H_5I = \underset{\text{Ether.}}{C_2H_5{-}O{-}C_2H_5} + KI.$$

What is then the chemical constitution of ether?

Two univalent alcoholic radicals united by a bivalent oxygen.



$$C_2H_5{-}O{-}C_2H_5 = \begin{matrix}C_2H_5\\C_2H_5\end{matrix}{>}O = (C_2H_5)_2O.$$

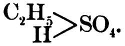
How do the alcoholic radicals behave chemically?

Like the metals.

How is ether produced on a large scale?

In two reactions.

1. Ethyl alcohol is acted on by H_2SO_4, the alcoholic radical takes the place of one H of H_2SO_4, forming ethyl-sulphuric acid. $C_2H_5OH + H_2SO_4 = C_2H_5HSO_4 + H_2O$ = Ethyl-sulphuric acid= $\begin{matrix}C_2H_5\\H\end{matrix}{>}SO_4$.



2. The ethyl-sulphuric acid (sulphovinic acid) with another molecule of alcohol forms the oxide of two ethyl radicals and sulphuric acid is set free again.

$$C_2H_5HSO_4 + C_2H_5OH = C_2H_5{-}O{-}C_2H_5 + H_2SO_4.$$

Does ethyl-sulphuric acid act by catalysis, and what is catalysis?

It does not act by catalysis. Catalysis means the action by the presence of a body, and is really chemically an undefined term.

Is the term sulphuric ether for ether a correct one?

No; because it contains neither sulphuric acid nor sulphur.

What are the properties of ether?

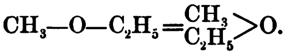
It is a colorless, limpid, mobile liquid, of sharp burning taste and a characteristic ethereal odor, sp. gr. 0.723, boils at 34.5° C., slightly soluble in water; it is highly inflammable, and when mixed with air it is explosive.

In regard to their use as anæsthetics, what is to be observed with ether and chloroform respectively?

Ether can be administered without access of air, but chloroform should always be administered with access of air; ether is inflammable, both in substance and its vapors as well. Chloroform is not inflammable.

What are mixed ethers?

Ethers that have two different alcoholic radicals; *e. g.*, methyl-ethyl ether.



$$CH_3{-}O{-}C_2H_5 = \begin{matrix}CH_3\\ C_2H_5\end{matrix}\!>O.$$

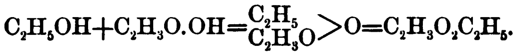
What are compound ethers?

Compound ethers, sometimes termed esters, are compounds containing one univalent alcoholic radical united by oxygen to a monobasic acid radical.

What do these compounds correspond to?

To the salts of inorganic bodies, the alcoholic radical representing the electropositive, the acid radical the electronegative, both united by oxygen.

Give the reaction for the formation of acetic ether or ester.

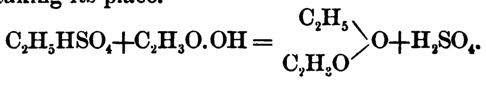


$$C_2H_5OH + C_2H_3O.OH = \begin{matrix}C_2H_5\\ C_2H_3O\end{matrix}\!>O = C_2H_3O_2C_2H_5.$$

Alcohol. Acetic acid. Acetic ether=ethyl acetate.

In making acetic ether or compound ethers of weaker acids what has to be done?

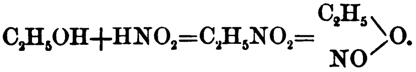
A little sulphuric acid has to be added to make first ethyl-sulphuric acid; this in turn is converted into H_2SO_4, the acid radical taking its place.



$$C_2H_5HSO_4 + C_2H_3O.OH = \begin{matrix}C_2H_5\\ C_2H_3O\end{matrix}\!>O + H_2SO_4.$$

What is nitrous ether, and how formed?

By the action of nitrous acid on alcohol.



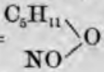
$$C_2H_5OH + HNO_2 = C_2H_5NO_2 = \begin{matrix}C_2H_5\\ NO\end{matrix}\!>O.$$

Alcohol. Nitrous ether.

Into which Pharmacopœial preparation does this enter?

Into the spiritus ætheris nitrosi, which should contain 5 per cent. nitrous ether and 95 per cent. alcohol.

What compound amylic ether is largely employed in medicine?



The amyl nitrite $C_5H_{11}NO_2 = \begin{matrix}C_5H_{11}\\NO\end{matrix}\!\!>\!O$ formed by the action of nitrous acid on amylic alcohol.

$$C_5H_{11}OH + HNO_2 = C_5H_{11}-O-NO + H_2O.$$

Describe the properties of amyl nitrite and its use in medicine.

It is a yellow liquid, sp. gr. 0.877, boils at 95° C., insoluble in water, soluble in alcohol; when diluted it has a pleasant, but concentrated suffocating odor, flushing the face by paralyzing the peripheral capillaries and thereby relieving cardiac tension; it is used in angina pectoris, also in asthma, 5–6 drops being inhaled.

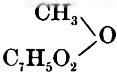
Where are the compound ethers profusely found in nature?

As flavors in fruits and essential oils.

Can these flavors or oils be produced artificially?

They can be produced artificially to resemble the natural flavors very closely. If judiciously employed they are not necessarily injurious.

Which essential oil can be artificially produced?



The oil of wintergreen, which is principally methyl salicylate, $\begin{matrix}CH_3\\C_7H_5O_2\end{matrix}\!\!>\!O$, and can scarcely be distinguished from the artificial product.

What are fats considered chemically?

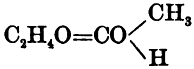
Fats are, in their chemical construction, ethereal salts or compound ethers and are acted on by alkaline hydrates like these. The process in the case of fats is termed saponification, and the product soap.

Aldehydes.

What is an aldehyde?

Dehydrogenated alcohol in which O^{II} takes the place of HO and an additional H.

$$C_2H_5OH+O=C_2H_4O+H_2O$$



$$C_2H_4O=CO\begin{cases}CH_3\\H\end{cases}$$

What is methyl aldehyde?

Formic aldehyde, $CH_2O=H-\overset{\overset{\displaystyle O}{\|}}{C}-H$, so called because it is formic acid CH_2O_2 minus O, and can be converted into this by oxidation.

What is ethyl aldehyde, and what else is it called?

C_2H_4O; it is also called acetic aldehyde or acetaldehyde, because it is acetic acid minus O, $CH_3.CO_2H$ minus $O=CH_3COH$, and because it can be converted into acetic acid by oxidation.

What group or radical is present in all aldehydes?

The radical $(COH)^I$.

What is paraldehyde?

$C_6H_{12}O_3$, a polymere of C_2H_4O with a vapor density three times that of aldehyde; it is a colorless liquid, sp. gr. 0.994, boiling at 124° C., of ethereal odor, and has a sharp, burning taste.

For what purpose is paraldehyde used in medicine?

It is a valuable hypnotic, similar to chloral hydrate, but said not to have the cardiac depressing effect of the latter.

Chloral, what is it?

A trichloraldehyde, CCl_3COH, from which its name is derived.

How is chloral prepared?

By the action, for some time, of chlorine on alcohol, considerable heat being developed, and the alcohol has to be maintained at a low temperature.

Describe the reaction by which it is formed.

It may be considered to take place in two stages, aldehyde being formed in one and chlorine substitution taking place in another as follows :—

1. Ethylic alcohol=$CH_3CH_2OH+2Cl=CH_3COH+2HCl$.
   Ethylic alcohol. Ethylaldehyde.
2. $CH_3.COH+6Cl=CCl_3COH+3HCl$.
   Ethylaldehyde. Chloral.

What is chloral hydrate?

Chloral with water forms chloralhydrate

$$CCl_3.COH+H_2O=CCl_3CH.(OH)_2.$$

Chloral. Chloralhydrate.

A white crystalline solid, fusing at 57° C., boiling at 98° C., volatile, soluble in water, of ethereal odor, and a sharp, burning taste.

How does chloral behave with the alkaline hydrates?

It forms alkaline formitates and chloroform.

$$CCl_3.COH+KOH=CHCl_3+KCO.OH.$$

Does chloral decompose in the body like this?

No, as it is eliminated undecomposed ; and besides its action is different from that of chloroform.

How does chloral act as a poison?

By its cardiac depressing action it produces heart failure.

What is the effect of chronic chloral poisoning in the chloral habit?

It deteriorates the blood, produces extravasations in spots, and scorbutic symptoms.

Describe the treatment for acute chloral poisoning—chloral coma.

Cardiac stimulants, application of hot cloths or mustard to the præcordium, keeping the body warm. Physiological antidote: strychnine.

Monobasic Acids.

What is the general formula of these acids, and under what name are they known?

Their general formula is $C_nH_{2n}O_2$; they are known as the volatile fatty acids.

Which are the principal members of this group, and their formulas?

Formic acid $CHO.OH$.
Acetic acid $C_2H_3O.OH$.
Proprionic acid $C_3H_5O.OH$.
Butyric acid $C_4H_7O.OH$.
Valerianic acid $C_5H_9O.OH$.
Caproic acid $C_6H_{11}O.OH$.

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Palmitic acid $C_{16}H_{31}O.OH$.
Stearic acid $C_{18}H_{35}O.OH$, etc.

What are these acids chemically?

Products of complete oxidation of the alcoholic radical CH_3, characterized by the group $CO.OH$.

Which is the acid corresponding to methyl?

Formic acid, $CH_2O_2=CHO.OH$; the acid of ants, also found in the fibres of nettles, pines, etc.; it is present in the body as an intermediate compound in the spleen and blood of persons suffering from leukæmia.

What is the acid corresponding to the radical ethyl?

Acetic acid $CH_3.CO.OH=C_2H_4O_2$, the acid produced by the action of mycoderma aceti oxidizing ethylic alcohol.

$$C_2H_5OH+O_2=C_2H_4O_2+H_2O;$$

also derived in the destructive distillation of wood.

What is the acidum aceticum U. S. P.?

A pure acetic acid, sp. gr. 1.047, containing 36 per cent. $C_2H_4O_2$.

Which is the purest form of acetic acid?

Glacial acetic acid, a crystalline solid of characteristic and penetrating odor, and of caustic action.

Vinegar, what is it?

An impure dilute acetic acid, derived by the acetous fermentation of alcoholic liquids, such as wines, cider, etc.

Which is the principal contamination of vinegar of the market, and how detected?

Sulphuric acid, detected by adding cane sugar and evaporating, when the latter will turn black if H_2SO_4 is present.

What is butyric acid?

$C_4H_7O.OH$, occurs in the secretions, in rancid butter and in cheese, giving them their rank odor. As a compound ether, glyceryl-butyrate $C_3H_5(O.C_4H_7O)_3$, it gives a pleasant odor and taste to butter, and as amyl-butyrate the odor of pineapple.

When is buytric acid present in the stomach?

It is present in the stomach and intestines pathologically in indigestion, owing to the putrid decomposition of carbohydrates.

What is valerianic acid, where found, and in what combinations?

$C_5H_9O.OH$, found as compound ether in the valerian root, and as ammonium valerianate in the secretions, especially of small-pox, typhus fever, yellow fever, giving these diseases their characteristic odors; it is also present in the fæcal excretions.

What is caproic acid?

$C_6H_{11}O.OH$, is present in butter, in the fæces, and perspiration.

What is palmitic acid?

$C_{16}H_{31}O.OH$, occurs in glyceride or glyceryl salt, in palm oil, and olive oil, and nearly all animal and vegetable fats. It is a white crystalline, odorless, and tasteless solid, insoluble in water, but soluble in alcohol and ether.

What is stearic acid?

$C_{18}H_{35}O.OH$. The most abundant of all fatty acids, present as a glyceride in all solid fats and oils. It is a colorless, odorless, and tasteless solid, insoluble in water but soluble in alcohol and ether; it is used in the manufacture of candles.

To what series of acids does oleic acid belong?

To the acrylic series of the general formula $C_nH_{2n-2}O_2$.

What is oleic acid?

$C_{18}H_{33}O.OH$, occurring as a glyceride, triolein, in nearly all fats. It is a colorless or slightly yellowish liquid, odorless when pure, and does not redden litmus. It oxidizes rapidly on exposure to air. With nitric acid it changes to a crystalline isomer elaidic acid.

What are the medicinal oleates?

Compounds of oleic acid with various bases or metals used for dermic medication; those in use are the oleates of mercury, zinc, lead, copper, and of the alkaloids.

What are mono- di- and triatomic alcohols?

Monatomic alcohols are those in which the radical is united with one OH, diatomic with two OH, and triatomic with three OH. The monatomic resemble KOH, the diatomic $Ca(OH)_2$, the triatomic $Fe_2(OH)_6$ (1 and 3).

Which is the most important triatomic alcohol, and what is it?

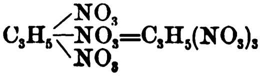
Glycerin $C_3H_5(OH)_3$; it is the triatomic alcohol of the radical glyceryl $C_3H_5\equiv$.

Describe the physical properties of glycerin.

It is a colorless, odorless, syrupy liquid of sweetish taste, sp. gr. 1.25, at 15.5° C., soluble in water and alcohol, insoluble in ether; it is a good solvent for many bodies, is antiseptic, withdrawing water from other bodies.

What results on treating glycerin with nitric acid?

A compound ether, trinitroglycerin, ordinarily termed nitroglycerin $C_3H_5\begin{cases}NO_3\\NO_3\\NO_3\end{cases}=C_3H_5(NO_3)_3$ is formed.



$$C_3H_5\begin{cases}NO_3\\NO_3\\NO_3\end{cases}=C_3H_5(NO_3)_3$$

Describe the physical properties of nitroglycerin.

It is a heavy viscid liquid, very poisonous, explodes with terrific force, and when mixed with other substances it is variously known as dynamite, giant powder, rendrock, etc.

Is nitroglycerin used medicinally, if so, in what form, and what is its effect?

It is used medicinally, acting like all the nitrites by relaxing the peripheral arterioles and capillaries thereby relieving cardiac tension. It is used in form of a 1 per cent. solution in alcohol.

What are fats?

Usually a mixture of olein, palmitin, and stearin in varying proportions.

What are the oleins, palmitins, and stearins chemically?

Glycerides or compound ethers of the radical glyceryl with three molecules of the radicals of oleic, palmitic, or stearic acids.

Give the formulas for them.

Olein=$C_3H_5(C_{18}H_{33}O.O)_3$.
Palmitin=$C_3H_5(C_{16}.H_{31}O.O)_3$.
Stearin=$C_3H_5(C_{18}H_{35}O.O)_3$.

Glyceryl tri-oleate, glyceryl tri-palmitate, glyceryl tri-stearate.

What is produced by the action of KOH or NaOH on these? Illustrate them.

Soaps are formed, the process being termed saponification.

$$\underset{\text{Stearin.}}{C_3H_5(C_{18}H_{35}O.O)_3}+3KOH=\underset{\text{Glycerin.}}{C_3H_5(OH)_3}+\underset{\text{Potassium stearate.}}{3KC_{18}H_{35}O_2}.$$

What are soaps then, and in what do they differ?

Salts of oleic, palmitic, or stearic acid, or mixtures of these three. Those made with KOH are of soft consistence, and are termed soft soaps; soda soaps are hard.

How do the neutral fats behave under the action of pancreatin in the body, or when treated with superheated steam?

They split up into glycerin and the fat acids.

Name the principal properties of fats.

They are more or less unctuous, insoluble in water, soluble in ether, chloroform, and carbon disulphide ; by means of certain media they form opaque mixtures with water known as emulsions.

What becomes of the fats ingested ?

Part of them is absorbed as such, others are decomposed by pancreatin, forming soaps with the alkalies, or, if not decomposed, they are emulsified ; all of it is rapidly oxidized in the body.

From what are fats derived besides from those ingested ?

From the proximate principles ; the smaller portion from the carbohydrates, the greater from the proteids.

What is the province of adipose in the body ?

It is stored up to furnish heat, and ready to be consumed if needed ; that part which is not stored produces heat directly.

When and in what condition does fat occur in the urine ?

When there is a direct communication established with the thoracic duct, as in chyluria ; the urine in such conditions appears milky from admixed emulsified fats ; this may be separated by shaking the urine with ether after adding a little KOH.

What are some of the tests for fats ?

Insolubility in water, solubility in ether, their inflammability, tendency to emulsify and form soaps, also their power to arrest the gyratory movements of camphor in water.

What other emulsifying agent is there in the body besides pancreatin ?

Alkali albumin, present in the intestine, forms emulsions with fats, furnishing envelopes for the fat globule.

Which is the typical natural emulsion ?

Milk, in which the fat is emulsified by a proteid—casein.

What is butter ?

A mixture of the glyceryl compounds of myristic, oleic, palmitic, stearic, caproic, and butyric acids.

How is butter made artificially, and what called? How distinguished from butter?

Oleomargarin or butterin is made artificially by expressing suet, and deriving the softer fats therefrom, and then mixed with milk and colored; the principal test between it and butter is the difference in their melting points.

What is lecithin?

A compound of cholin, $C_5H_{15}NO_2$, with glycero-phosphoric acid and fatty acids, present in nerve and brain tissue, and in the yelks of eggs.

What are olefins, and which is the most important member of this group?

The unsaturated hydrocarbons of the general formula C_nH_{2n}; the most important of these is ethene or ethylene or olefiant gas, $C_2H_4^{II}$, the principal constituent of illuminating gas.

Which of the alcohols corresponding to C_2H_4 is of importance?

The diatomic alcohol known as glycol, $C_2H_4(OH)_2$.

What acid results by the complete oxidation of this alcohol?

A diatomic and dibasic acid, known as oxalic acid.

$$C_2H_2O_4=C_2O_2(OH)_2.$$

State its principal occurrence and properties.

It is a crystalline solid, fusing in its water of crystallization, and subliming without decomposition; it exists in various plants, principally the sorrel, and may be artificially prepared by the action of HNO_3 on sugar or cellulose.

For what purposes is it commonly used?

For cleaning metals, removing ink and iron stains, etc.

Which is the principal compound of oxalic acid?

Potassium oxalate, or better, acid- or hydro-potassium oxalate, also termed potassium binoxalate, KHC_2O_4+Aq.

What is salts of lemon, and why does its name give rise to serious mistakes?

Salts of lemon is potassium oxalate, used for removing ink stains; on account of its similarity in appearance to Epsom salts it is often mistaken for it with fatal results; also, the term, salts of lemon, inducing the belief that it is derived from lemons, and may be used in making lemonade.

Is oxalic acid poisonous, and what is its action?

In strong solutions or in substance it acts as a corrosive, by absorption from dilute solutions as a neurotic poison; death may ensue promptly after taking it or even weeks afterwards.

What is the treatment for poisoning by oxalic acid?

Treatment to be available should be instituted at once, and consists of raw eggs, alkaline earths, magnesia in milk, chalk, plaster from the wall, etc.; avoid diluent drinks or alkaline carbonates, they form soluble poisonous compounds readily absorbed.

Which are the principal tests for oxalic acid?

$AgNO_3$ gives a white precipitate, which, when dry, explodes on heating; calcium hydrate or soluble salts of calcium give white precipitates insoluble in weak acids, soluble in HCl or HNO_3.

Which is the principal monobasic acid of this series?

Lactic acid, $C_3H_6O_3$, existing in two, if not three isomeric conditions. Ordinary lactic acid is present in the gastric juice, and is a fermentation product of milk; it is a colorless, syrupy liquid of sour taste, and is optically inactive.

What is the tartaric acid of the Pharmacopœia?

A crystalline solid, $C_4H_6O_6$, one of a member of four acids of that formula, soluble in water and alcohol, of acid taste and reaction, charring at red heat; its solution develops a fungus on standing which decomposes it; it is tetratomic and dibasic.

What are the principal officinal compounds of tartaric acid?

Acid or hydropotassium tartrate, termed cream of tartar, $KHC_4H_4O_6 = KH\overline{T}$.

Sodium potassium tartrate, $KNaC_4H_4O_6 = KNa\overline{T}$.

What is citric acid?

A crystalline solid, $C_6H_8O_7 + Aq$, of acid taste and reaction, very soluble in water. It occurs in lemons, oranges, and other fruits. Citric acid and its salts are decomposed in the economy into CO_2 and carbonates rendering the urine alkaline ; it is tribasic.

What are terpenes?

Unsaturated hydrocarbons of the general formula C_nH_{2n-4}.

Which is the most important member of this group?

Terebenthene, $C_{10}H_{16}$, on account of having a great number of isomeres in the volatile or essential oils, varying according to their physical properties, odor, and optical behavior.

Which are some of the principal terebenthenes used medicinally?

Turpentine U. S., the viscid juice exuding from pine, abies, etc., also white turpentine, Canada turpentine or balsam of fir, Venice turpentine, Chian turpentine, and oil of turpentine.

What is oil of turpentine?

Oil or spirits of turpentine is the distillate from turpentine, containing principally terebenthene; it is a colorless, limpid, neutral liquid, sp. gr. 0.86, oxidizing rapidly when exposed to the air, used medicinally as a diuretic and stimulant.

When oil of turpentine is treated with sulphuric acid what results?

Terpine hydrate, $C_{10}H_{16}2H_2O+H_2O$, a white crystalline solid without taste or odor, soluble in hot water, alcohol, and ether.

What is caoutchouc and what gutta-percha?

They are both hydrocarbons, closely related to terebenthene; caoutchouc, also termed India-rubber, when melted with sulphur forms what is known as vulcanized rubber, and when the amount of sulphur is increased forms hard rubber; gutta-percha is a concrete juice of elastic consistence, which when dissolved in chloroform is the liquor gutta-percha U. S.

Camphors and resins, what are they?

They may be regarded as oxidized terpenes, usually obtained directly from plants.

Which is the ordinary camphor?

Laurel or Japan camphor, $C_{10}H_{16}O$, exists in several modifications; it is a colorless, transparent mass, volatile, soluble in alcohol, ether, and turpentine; sp. gr. 0.985.

What is camphoric acid?

A crystalline substance, $C_{10}H_{16}O_4$, obtained by boiling camphor with HNO_3.

What is menthol?

A camphor contained in the essential oil of peppermint, really a menthyl alcohol, $C_{10}H_{20}O$, a crystalline, colorless solid, soluble in alcohol, ether, carbon disulphide, and acids.

What forms the benzene or aromatic group?

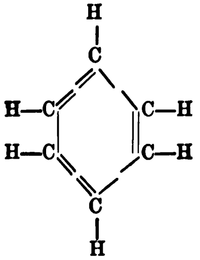
Unsaturated hydrocarbons of the general formula C_nH_{2n-6}.

Which is the first and principal member of this group?

Benzene, C_6H_6, a colorless, mobile liquid, of characteristic odor, sp. gr. 0.86, boiling at 80.5° C.; a good solvent for many resins, fats, and other substances, readily inflammable, burning with a smoky flame.

How can the constitution of the benzene molecule be graphically demonstrated?

By arranging it according to Kekulé, in a closed chain, in which the carbon atoms exchange alternately one or two valences,



the hydrogens of which are subject to substitution as in other hydrocarbons.

What is the radical corresponding to benzene?

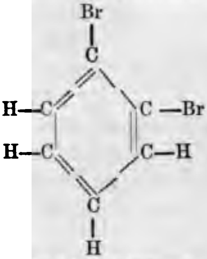
Phenyl, C_6H_5—, a monad.

Can the mono-substitution compound of this molecule produce isomeres?

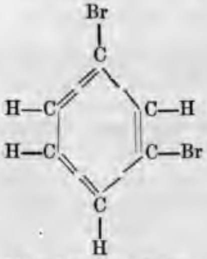
No; because the replacing of any one of the H leaves the others in the same relation to it.

How can the di-hydrogen substitution compounds of this molecule differ?

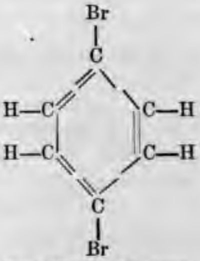
According to the manner in which they are substituted three isomeres may result.



Ortho-dibromo-benzene.



Meta-dibromo-benzene.

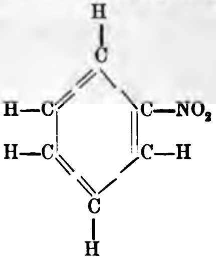


Para-dibromo-benzene.

The immediate substitution producing ortho-, the intermediate meta-, and the opposite para-substitution compounds.

What is the nitrobenzene compound of benzene?

Nitrobenzene, $C_6H_5\,NO_2$,



$$C_6H_6+HNO_3=C_6H_5NO_2+H_2O.$$

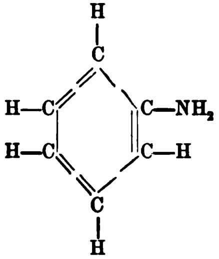
A yellow oily liquid, of the odor of bitter almonds, also termed oil of myrbane, largely used in perfumery, and sometimes with disadvantage as a flavor, as it is very poisonous, producing unconsciousness, difficulty of respiration, cardiac irregularity, convulsions, and coma.

How can nitrobenzene be distinguished from the oil of bitter almonds?

By reducing the former with acetic acid and iron-filings amidobenzene or aniline is formed.

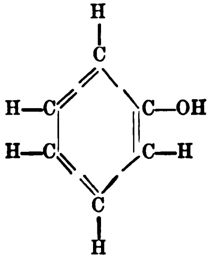
$$C_6H_5NO_2+6H=C_6H_5NH_2+2H_2O.$$

What is the graphical formula of aniline?



Which is the principal alcohol corresponding to benzene?

C_6H_5OH



phenyl hydrate, phenol, also, but erroneously, termed carbolic acid, phenic and phenylic acid, principally obtained by the fractional distillation of coal tar, from which it passes between 150-200° C.

What are the physical properties of carbolic acid?

A crystalline colorless solid when anhydrous, of characteristic odor; it melts at 35° C., and if 5 per cent. of water is then added to it it remains liquid; exposed to light it turns red without deterioration.

For what purpose is carbolic acid employed in surgery?

As an antiseptic and germicide, as a lotion and dressing for wounds, etc.; it acts like a protoplasmic poison.

How does carbolic acid act locally?

It produces a white eschar on the skin with a feeling of numbness, and is for that reason employed as a local anæsthetic; it coagulates and condenses the mucous membranes, leaving hard white eschars; at times it is absorbed from wounds and produces systemic effects.

What is the toxic action of carbolic acid?

It is a neurotic poison; stops the heart in diastole, produces giddiness, insensibility, and heart failure.

What are the antidotes for carbolic acid?

Olive oil, castor oil, stomach-pump, saccharated lime, magnesia.

By what tests is carbolic acid recognized?

Its odor; yellow crystals of picric acid forming when it is acted on by HNO_3; purple color on addition of a ferric salt, a greenish color on addition of NH_4OH followed by sodium hypochlorite; a yellowish-white precipitate when added to bromine water; Millon's reagent (mercurous nitrate $+HNO_3$) gives with it a red color when warmed (detects 1 in 200,000).

What is the result of treating phenol with nitric acid?

Trinitrophenol or picric acid, $C_6H_2(NO_2)_3OH$. Crystallizing

$$C_0H_5OH+3HNO_3=C_6H_2(NO_2)_3OH+3H_2O$$

in brilliant yellow six-sided prisms or plates; is of a very bitter taste, not easily soluble in water, readily so in alcohol, ether, and benzene.

For what purposes is picric acid used?

For staining tissues yellow, also for dyeing, as a precipitant for albumin and alkaloids, and for determining sugar in urine quantitatively.

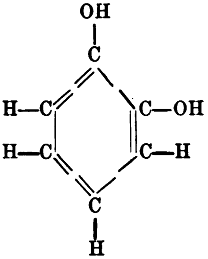
From what besides phenol may picric acid be produced by nitric acid?

From various organic bodies, such as indigo, aniline, resins, silk, leather, wool, and albuminoids.

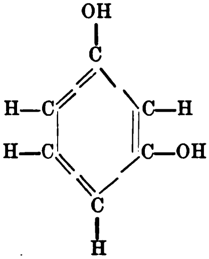
Which are the diatomic hydrates corresponding to benzene?

Three isomeric substances, called respectively pyrocatechin, resorcin, hydroquinone, are sometimes comprised under the term oxyphenols, $C_6H_4(OH)_2$.

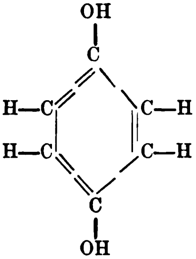
Give the graphical formulas of these.



Pyrocatechin, oxyphenic acid, catechol.



Resorcin or resorcinol.



Hydroquinone.

Which of the three is used in medicine, and to what purpose?

Resorcin, occurring in colorless and odorless short rhombic prisms, freely soluble in water, alcohol, and ether; it has been used as an antipyretic, a local caustic, and alterative.

What is toluene?

Another member of the aromatic series, of the formula C_7H_8, which may be viewed as a methyl benzene, $C_6H_5.CH_3$; a colorless liquid of characteristic odor, obtained from coal tar and the dry distillation of tolu balsam and other resins.

What alcohol corresponds to toluene?

Benzylic alcohol or benzoic alcohol, benzyl hydrate, $C_6H_5.CH_2OH$.

Which acid corresponds to this?

Benzoic acid, $C_6H_5.CO.OH$, crystallizing in white shining needles or plates, either odorless when pure or of a pleasant odor of benzoin when prepared from this by sublimation; it is of acid reaction, monobasic, and forms salts termed benzoates.

When benzoic acid is ingested in what form is it eliminated?

As hippuric acid, $C_9H_9NO_3$, benzyl glycocoll or benzyl-amido-acetic acid, which gives the urine an acid reaction; it is largely found in the urine of herbivora.

What is salicylic acid?

$C_6H_4(OH).CO.OH$, oxybenzoic acid, crystallizing in white needles, somewhat soluble in water, readily soluble in alcohol and ether; it may be obtained from oil of wintergreen, in which it exists as methyl salicylate, but is manufactured principally from phenol; it is a valuable antiseptic and medicinal agent.

What is gallic acid?

$C_6H_2(OH)_3CO.OH$, crystallizing in silky needles, of acid taste, slightly soluble in cold water, freely soluble in hot water and alcohol. It is obtained from nutgalls by converting the tannic acid by a fermentative process into gallic acid and extracting the latter by hot water.

Benzoic aldehyde, what is it?

Benzaldehyde, $C_7H_6O=C_6H_5CHO$, is an essential oil of bitter almonds; a colorless or yellowish liquid of characteristic odor, sp. gr. 1.050, boils at 179° C. It is obtained by the action of emulsin ferment on amygdalin, oil of bitter almonds, hydrocyanic acid and glucose being formed. Owing to the presence of hydrocyanic acid it is poisonous.

What is cholesterin?

Cholesteric alcohol, $C_{26}H_{43}OH$, largely found in the animal economy, and sometimes abnormally in the biliary secretions; when in the latter it separates to form gallstones.

How may cholesterin be recognized?

By being soluble in hot ether and alcohol, from which it separates on cooling in rhombic plates; with H_2SO_4 it turns red, and on addition of water or chloroform to this it changes to green.

What is naphthalene?

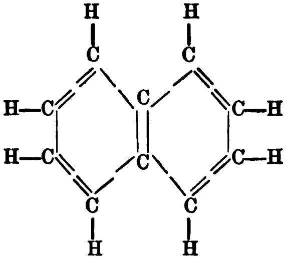
$C_{10}H_8$, a white crystalline solid of characteristic odor and unctuous touch, insoluble in water, readily soluble in ether; it is the principal member of the unsaturated hydrocarbons of the general formula C_nH_{2n-12}. It is obtained by the fractional distillation of coal tar.

What are its principal uses in medicine?

It is a valuable and non-poisonous antiseptic, and is largely used as an insecticide (moth destroyer).

Describe the arrangement of its molecule and give its graphical formula.

It is constituted of two benzene molecules united by two of their carbons, thus :—



What are the two hydrates of naphthalene?

α naphthol and β naphthol, both having the formula $C_{10}H_7OH$; the β naphthol is largely employed as a valuable antiseptic.

Carbohydrates.

What compounds are known under this name?

Those composed of carbon, hydrogen, and oxygen, the carbon being present in groups of six or multiples thereof, and the hydrogen and oxygen in the proportion as in water.

Give the principal groups of carbohydrates and their formulas.

Celluloses. $(C_6H_{10}O_5)_n$	Saccharoses. $C_{12}H_{22}O_{11}$	Glucoses. $C_6H_{12}O_6$
Cellulose,	Cane sugar,	Grape sugar (dextrose),
Starch,	Milk sugar,	Fruit sugar (laevulose),
Glycogen,	Maltose,	Galactose,
Dextrin,	Melitose,	Arabinose.
Gums.	Melezitose.	

Which is the purest form of cellulose?

Cotton, gossypium, deprived of its fat it is known and used in medicine as absorbent cotton.

What results when cellulose is treated with H_2SO_4?

It first swells up and dissolves to form dextrin, which, when diluted with water and boiled, changes into glucose.

How is parchment paper made?

By dipping unsized paper for a little while into sulphuric acid and washing it well before drying.

What is pyroxilin, and how produced?

Nitrocellulose, gun-cotton, or collodium-cotton, is produced by the action of HNO_3 on cellulose.

Give the formula for pyroxilin.

It may be either di-nitrocellulose, $C_6H_8O_5.(NO_2)_2$, as in collodium-cotton or tri-nitrocellulose, gun-cotton, $C_6H_7O_5.(NO_2)_3$.

What is collodium, and what its varieties?

Collodium is a solution of pyroxilin in alcohol and ether, used in surgery, etc., for forming an artificial skin; as it contracts very much on drying, it is made more flexible by the addition of 5 per cent. of Venice turpentine and 3 per cent. of castor oil. When mixed with the ethereal extract of cantharides it forms cantharidal collodium or blistering paint; when mixed with tannin it is known as styptic collodium.

What is celluloid?

A solution of camphor in collodium, forming on evaporation of the ether a mass which is plastic while warm and hard at an ordinary temperature.

Which is the most important of the celluloses?

Amylose or starch (amylum), the fecules found in the roots, tubers, grains, etc., of plants; it is insoluble in cold water, and separated by washing it from the crushed grain with cold water.

What is the proportion of starch and gluten in wheat flour?

Starch 72 per cent. and gluten 11 per cent.

Describe the shape, structure, and proximate composition of starch fecules.

They are granular, irregularly oval, and of characteristic structure; their centre is termed the hilum, which is surrounded by concentric layers or lamina; they are composed of cellulose and granulose.

Are all fecules of starch from various sources alike, and what is their common characteristic?

Starch fecules from different sources vary, but all are polarized in characteristic form, representing a Maltese cross centred in the hilum.

By what tests can starch be recognized?

1. Starch is insoluble in cold water, but on boiling forms a transparent mucilage or gelatinous mass; this when diluted sufficiently is known as starch-water.

2. Treated with a solution of iodine starch gives rise to a bluish-black precipitate, which is dissolved by KOH or Cl, and also by heat.

3. Boiled with dilute acids starch is converted into dextrin and glucose.

$$\underset{\text{Starch.}}{3C_6H_{10}O_5}+H_2O=\underset{\text{Glucose.}}{2C_6H_{12}O_6}+\underset{\text{Dextrin.}}{C_6H_{10}O_5}.$$

What is dextrin?

One of the celluloses, sometimes termed British gum, and is obtained by exposing starch to dry heat of 175° C. It is a yellow amorphous powder, soluble in water, forming mucilage; with iodine it gives a red color, and does not reduce alkaline cupric solutions.

Which of the celluloses are termed gums?

Carbohydrates, soluble in water, insoluble in alcohol, and capable of being converted into glucose by H_2SO_4; the principal members of this group are acacia and tragacanth.

Glycogen, what is it, where found, properties, and destiny?

Animal starch, belonging to this group, is found in the liver, in the muscles, in oysters, and in embryonic structures; it is principally derived from carbohydrates, but also from proteids. It is probable that it furnishes muscle energy, as there is less present in the muscles after muscular efforts; it is claimed to be stored up in the liver as colloidal glucose, from which it can be changed into diffusible glucose by a special ferment; it is not present in the blood.

Which carbohydrates are known as saccharoses?

Those having the formula $C_{12}H_{22}O_{11}$.

Which is the principal one, and where found?

Cane sugar, found in sweet fruits, and other parts of saccharine plants, such as sugar-cane and beet-root, from which it is obtained by expression and crystallization.

What are the different forms of cane sugar?

Ordinary table sugar, rock candy, lower grades, molasses or treacle and caramel; molasses remains after the crystallization of the former; caramel is burned sugar forming at 210° C., used for coloring liquors.

What are the properties of cane sugar?

It is very sweet to the taste, of monoclinic crystalline structure (oblique prisms), dextro-rotatory; boiled with dilute acids it is hydrated into dextrose and laevulose.

$$\underset{\text{Cane sugar.}}{C_{12}H_{22}O_{11}} + H_2O = \underset{\text{Glucose.}}{C_6H_{12}O_6} + \underset{\text{Laevulose.}}{C_6H_{12}O_6}$$

Why is the latter called inverted sugar?

Because the rotatory power exercised on it by polarized light is inverted, *i. e.*, laevo-rotatory; laevulose is sweeter than glucose but uncrystallizable.

Describe the distinctions between glucose and cane sugar.

Cane sugar does not reduce the alkaline cupric solutions directly; it does not ferment as such, but has to be converted into glucose first; cane sugar chars with H_2SO_4, glucose does not.

What is lactose, and how derived?

Sugar of milk $C_{12}H_{22}O_{11}+Aq$, made from the whey of milk as a by-product in the manufacture of cheese, crystallizing from this after concentration on foreign bodies, such as strings, sticks, etc., inserted into it.

Describe its properties.

It is crystalline, not so soluble nor so sweet as the other sugars, reduces the alkaline cupric solutions, is dextrorotatory and ferments, changing into alcohol, carbon dioxide and lactic acid (koumys).

Glucose, what is it?

Grape sugar or dextrose $C_6H_{12}O_6$, found on raisins, in honey, and derived from other carbohydrates such as starch, etc., also from glucosides by the action of dilute acids and ferments.

How is glucose manufactured?

By treating starch with H_2SO_4, precipitating the acid with $CaCO_3$ and concentrating the liquid.

For what purposes is glucose principally used?

As a substitute for the syrups of the market, honey and table syrups being largely glucose; the solid grape sugar is manufactured into candies to a great extent.

Is this substitution injurious to the health?

Not if the glucose is made from pure materials, as all sugars and carbohydrates have to be converted into glucose before they are assimilated.

Which is the most important chemical property of glucose?

That it reduces the metallic oxides.

Is glucose present in the urine in normal conditions, and in which disease is its presence abnormally great?

Minute traces of glucose are normally present in the urine, slightly increased at times by various physiological or pathological changes; when present in the urine in larger quantities and persistently, it characterizes the disease known as diabetes mellitus.

What caution should be observed in testing urine for glucose?

That it should contain no albumin; if present, it should first be separated by boiling and subsequent filtration.

What is Moore's test for sugar in urine?

To boil for a few moments a mixture of equal parts of the urine and KOH solution. If glucose is present the mixture will turn deep yellow or brown.

What is Boettger's test?

The alkaline bismuth test; boil equal parts of urine and KOH solution to which a pinch of bismuth subnitrate is added; if glucose is present the white bismuth salt will turn dark gray or black, being reduced to metallic bismuth. (*See* Bismuth.)

Is this test always admissible?

If albumin or sulphur compounds are present it is not; to ascertain this boil with litharge first instead of the bismuth, if the litharge blackens, this test cannot be employed.

Which is the principal test for sugar in urine?

The alkaline cupric test, in which the cupric oxide, held in solution by KOH or NaOH and some organic substance, is at the boiling point reduced to cuprous oxide. (For reaction, *see* Copper.)

Trommer's test, how is it performed?

To a little urine in a test-tube add an equal volume of KOH solution and a few drops of $CuSO_4$ solution. Heat to the boiling point; if sugar is present yellow or red cuprous oxide is precipitated.

Haines' test, how applied?

To some KOH solution in a test-tube add a few drops of solution of $CuSO_4$ and a few drops of glycerin; boil this and after removing from the flame add gradually some of the suspected urine; if glucose is contained in it, a yellowish-red precipitate of cuprous oxide will be thrown down.

What is Fehling's solution?

A solution of NaOH and sodium potassium tartrate (Rochelle salt), to which a solution of $CuSo_4$ is added.

State the disadvantage of Fehling's solution, and how obviated.

Fehling's solution does not keep well, and should therefore not be kept ready made for any length of time; to obviate this, the alkaline solution of Rochelle salt and the $CuSO_4$ solution should be kept separate, as follows:—

℞. $CuSO_4$ 34.64 grams, water q. s. to 500 c.c.

℞. Rochelle salt (crystallized) 173 grams, Sol. NaOH (sp. gr. 1.34) 100 c.c., water q. s. 500 c.c.

For use, mix equal volumes as needed.

How is glucose detected with Fehling's solution?

By boiling in a test-tube some of the solution, and after removing it from the flame add a little of the suspected urine or fluid; if no reaction takes place, heat again, and add more urine in the same manner; if glucose is present, yellow or red cuprous oxide will be precipitated.

In which way may glucose be quantitatively determined with Fehling's solution?

Place into a capsule, beaker, or flask 10 c.c. of Fehling's solution, diluted with 40 c.c. of water. Heat to the boiling-point, and let gradually run into it from a burette a mixture of one part of urine and nine of water, stirring the mixture until the blue color of the test solution has entirely disappeared. Repeat this several times until the amount of diluted urine used proves the smallest quantity effecting complete reduction.

How is the amount of glucose computed from this process?

As the 10 c.c. Fehling's solution can be reduced by exactly 0.05 glucose, the amount thereof present in the mixture of urine and water corresponds to this. As the quantity of the mixture used out of the graduated burette equalled $\frac{1}{10}$ of the urine to be examined, this (1 in 10) contained 0.05 grams of glucose. Thus if 16 c.c. diluted urine (1 in 10) were used, 1.6 c.c. urine contained 0.05 grams of glucose. To obtain the percentage the following proportion will answer: $1.6 : 0.05 = 100 : x$; $x = 3.1$ per cent.

What is Johnson's picric acid test for the quantitative determination of glucose in urine?

It consists of converting picric acid in the presence of KOH and glucose into reddish-brown picramic acid; the intensity of the color of the latter being proportionate to the amount of glucose present; the color of the picramic acid formed is then compared with that of a standardized solution of ferric acetate, and thus the amount of glucose ascertained.

How is this test performed?

Take of urine fʒj, liquor potassæ fʒss, solution of picric acid (gr. 5.3 to f℥j), m. xl. water q. s. ad fʒiv into a test-tube, and boil for sixty seconds; after which cool the mixture, and bring it up to the original volume (fʒiv). Of this pour 10 c.c. into a 100 c.c. graduated cylinder, which has attached to it a test-tube of equal diameter and containing the standard fluid; dilute the boiled mixture to equal in color the standard liquid, and for each 10 c.c. it has been diluted up to, count 1 grain of glucose in the ounce of urine tested.

What is the standard ferric acetate solution composed of?

℞. Liquor. ferri chloridi fʒj;
Ammonii carb. ʒj;
Acidi acetici fʒv;
Aquæ destillat. q. s. ad f℥iiiss.—M.

How is the quantity of glucose in urine determined by Roberts' differential density method?

Take the specific gravity of the urine to be tested, and take of this about 4 fluidounces, with this is mixed up a small quantity of compressed yeast; set aside for 24 hours in a warm place until fermentation is complete, and then take the specific gravity of the fermented urine; subtract this from the first amount, and for each degree of sp. gr. lost, there is one grain of glucose present in the fluidounce of urine.

By what other process may sugar be quantitatively determined?

By polarization.

What is polarized light?

When a ray of light passes through a feldspar prism (Nicol's prism), it is deflected in two directions, one of which is termed refracted and the other polarized.

What is the effect of sugar, proteids, and other optically active substances on polarized light passing through their solutions?

They deviate it in accordance with their individual composition and the density of their solutions.

What are polarizing saccharimeters, and what their component parts?

Instruments to ascertain the quantity of sugar in a fluid to be examined; they are composed of a polarizer, a container, an analyzer, and a gràduated arc for reading off the angle of deviation.

What is the specific angle of rotation of glucose, and how is the quantity of sugar computed from the observed angle?

$+56$, and the formula for computation is $\frac{100 \times \text{angle}}{56}$, thus if 2.8° were the observed angle the formula would read

$$\frac{100 \times 2.8}{56} = \frac{280}{56} = 5 \text{ per cent.}$$

Glucosides.

What are glucosides?

Various subacid or neutral principles obtained mostly from plants; they have the characteristic property of splitting up under the action of ferments or acids into glucose and other bodies.

As what may they be chemically regarded?

As compound ethers or ethereal salts of the glucoses.

Name the principal glucosides, and what is the rule adapted regarding their nomenclature?

Their names have the terminal syllable "in" in English and "inum" in Latin, in contradistinction to the alkaloids, which terminate respectively in "ine" and "ina." The principal ones of interest in medicine are amygdalin, colocynthin, digitalin, glycyrrhizin, jalapin, salicin, santonin, and the tannins.

What is amygdalin, and how does it split up?

A crystalline glucoside, $C_{20}H_{27}NO_{11}$, present in and obtained from bitter almonds, cherry-laurel leaves, wild-cherry bark, and other plants of the amygdaleæ and pomeæ. By the action of boiling dilute acids or the ferment emulsin it splits up into oil of bitter almonds, hydrocyanic acid, and glucose as follows:—

$$\underset{\text{Amygdalin.}}{CO_{20}H_{27}NO_{11}} + 2H_2O = \underset{\text{Oil of bitter almonds.}}{C_7H_6O} + \underset{\text{Glucose.}}{2C_6H_{12}O_6} + \underset{\text{Hydrocyanic acid.}}{CNH}$$

What is digitalin, and what does it split up into?

A complex body resolved into digitonin, digitalin, and digitalein; with H_2SO_4 it splits up into glucose and digitaliretin, $C_{15}H_{25}O_5$.

By what test may digitalin be recognized?

Dissolved in H_2SO_4 it yields a green color, which, on addition of bromine water, changes to a reddish-violet, and on dilution with water, emerald green.

What is salicin, and how does it split up?

A white crystalline glucoside, $C_{13}H_{18}O_7$, derived from the bark of the willow; with acids it splits up into glucose and saligenin.

Which glucoside is obtained from santonica?

Santonin, $C_{15}H_{18}O_3$, shining crystals which split up with acids into glucose and santoniretin.

Which is the tannin of the U. S. P.?

The glucoside obtained from nutgalls, also known as gallotannic acid; it is now regarded not as a tannin or glucoside proper but as a digallic acid; it has the formula $C_{14}H_{10}O_9$, and under the action of boiling dilute acids or alkalies it is changed into gallic acid.

$$\underset{\text{Gallotannic acid.}}{C_{14}H_{10}O_9} + H_2O = \underset{\text{Gallic acid.}}{2C_7H_6O_5}$$

Inversely gallic acid can be changed into gallotannic acid.

$$\underset{\text{Gallic acid.}}{2C_7H_6O_5} = H_2O + \underset{\text{Gallotannic acid.}}{C_{14}H_{10}O_9}$$

What are the reactions for gallotannic acid?

With solutions of ferric salts it gives dark bluish-black precipitates; no precipitate with ferrous salts, but gradually forming on exposure and oxidation; this is known as ink; with gelatin, albuminoids, and alkaloids it forms precipitates.

Substituted Ammonias.

What is meant by these?

Compounds forming on the ammonia type, *q. v.*

Which are the compounds so forming?

Amines, amides, imides, alkalamides, and amido-acids.

What are amines?

Ammonia NH_3, in which one or more H is replaced by electropositive (alcoholic) radicals.

Give the formulas of mono-, di-, and trimethylamine.

CH_3NH_2	$(CH_3)_2NH$	$(CH_3)_3N$
Methylamine, or primary methylamine.	Dimethylamine, or secondary methylamine.	Trimethylamine, or tertiary methylamine.

How do the amines behave towards acids?

They have basic properties like ammonia, and like it they unite directly with acids to form salts.

Amidogen, what is it?

The radical NH_2—.

What are amido-acids?

Monobasic or fatty acids, in which one H of the alcohol radical is substituted by amydogen, and having both acid and basic functions.

What is the most important one of these?

Amido-acetic acid, $CH_2NH_2.CO.OH.$, known as glycocol or glycine.

In what acid of the body is glycine contained?

In glycocholic acid, $C_{26}H_{43}NO_6$, found as sodium glycocholate in the bile and during icterus in the blood and urine.

How does glycocholic acid split up?

Into cholic acid and glycocol.

$$\underset{\text{Glycocholic acid.}}{C_{26}H_{43}NO_6} + H_2O = \underset{\text{Cholic acid.}}{C_{24}H_{40}O_5} + \underset{\text{Glycocol.}}{C_2H_5NO_2}.$$

Which other acid is associated with this in the bile?

Taurocholic acid, $C_{26}H_{45}NO_7S$, as sodium taurocholate.

Into what can this be split up?

Into cholic acid and taurin.

$$\underset{\text{Taurocholic acid.}}{C_{26}H_{45}NO_7S} + H_2O = \underset{\text{Cholic acid.}}{C_{24}H_{40}O_5} + \underset{\text{Taurin.}}{C_2H_7NO_3S}.$$

Under what name are these two acids commonly known, and by what reaction recognized?

They are known as the biliary acids, and recognized by the Pettenkofer's reaction.

How is the Pettenkofer's reaction applied, and what has to be done when used for testing urine or blood?

A minute quantity of cane sugar is added to their solutions, and this floated on H_2SO_4 in a test-tube, when a fine purple color will appear at their line of contact. In applying this to urine or blood, the fluids must be evaporated, the residue extracted with alcohol, and this mixed with ether, the precipitate resulting is dissolved with water and tested as above.

What is leucine?

Amido-caproic acid, $CH_3(CH_2)_3.CH.NH_2COOH = C_6H_{13}NO_2$, found in the urine of those suffering from hepatic diseases, principally in acute yellow atrophy, appearing as spheres under the microscope.

What other substance is associated in such conditions with leucine in the urine?

Tyrosine, $C_9H_{11}NO_3$, appearing under the microscope as stellar bundles or sheaves.

What is creatine and what creatinine?

Creatine, $C_4H_9N_3O_2$, methyl glycocyamine, is another amido-acid found in the animal organism, especially in the juice of muscles, and also in the brain, blood, and amniotic fluid. Creatinine, $C_4H_7N_3O$, a product of dehydration of creatin, is normally present in the urine, and obtained from this as a zinc compound by precipitation with zinc chloride.

When the hydrogen of ammonia is substituted by electronegative or acid radicals, what results?

Amides, thus acetamide is $CH_3O.NH_2$; if respectively one or more of the H of NH_3, they form primary, secondary, or tertiary amides; if a multivalent acid radical replaces one H in more than one group of NH_3, they are termed $\overline{R}$ di- or $\overline{R}$ tri-amide.

What is carbonyl di-amide?

Carbamide or urea, $CO''<^{NH_2}_{NH_2}=CON_2H_4$, an isomere of ammnium cyanate, $NH_4.CON$.

How does urea originate in the body, and how is it excreted?

Urea is the final product of elimination of all nitrogenous food entering the body; it is principally eliminated by the kidneys in quantities of about 500 grains daily; more or less influenced by the amount of albuminous food ingested and the condition of the skin, bowels, and kidneys.

What are the properties of urea?

It is neutral, odorless, of a cooling bitter taste, very soluble in water and alcohol, insoluble in ether; it crystallizes in four-sided transparent prisms with bevelled edges; it forms crystalline compounds with acids, bases, and salts.

How is the oxalate or nitrate of urea prepared from the urine?

By acidulating condensed urine either with oxalic or nitric acid, crystals of urea oxalate, $(CH_4N_2O)_2C_2H_2O_4+2Aq$, or urea nitrate, $CH_4N_2O.HNO_3$, separate on cooling.

What is the compound of urea with mercuric oxide?

A white precipitate of the formula $CH_4N_2O.3HgO$.

How is urea decomposed by sodium hypobromite or hypochlorite?

Into sodium chloride or bromide, carbon dioxide, water, and nitrogen.

$$N_2H_4CO+3NaBrO=3NaBr+CO_2+2H_2O+N_2.$$

In which way is this utilized?

In different processes for the quantitative determination of urea in the urine.

What is the differential density or Fowler's method for the determination of urea in urine?

The process of decomposing the urea therein with Labarraque's solution and comparing the loss of specific gravity, which is in direct proportion to the urea decomposed.

How is this process carried out?

Take the specific gravity of the urine accurately, also that of the liquor sodæ chloratæ; the latter multiply by 7, and to the product add the specific gravity of the urine; the sum of the two divided by 8 gives then the specific gravity of a mixture of 1 volume urine and of 7 of the hypochlorite solution. Then add 1 volume of urine to 7 of liquor sodæ chloratæ, allow the mixture to stand for several hours until effervescence has ceased, and take the specific gravity of the mixture; this subtracted from that representing the mixture before reaction gives the difference, which, if multiplied with 0.77, corresponds to the percentage of urea present in the urine.

On what process does Liebig's method for the quantitative determination of urea depend?

On the formation of urea compounds with mercuric oxide, a standard solution of mercuric nitrate being used with sodium bicarbonate as an indicator.

How is this process conducted?

Urine is deprived of its sulphates and phosphates with baryta water; after filtration it is titrated with the standard solution of mercuric nitrate, an excess of which is indicated by the sodium bicarbonate.

What is known as the Russell and West's method for determining the urea in urine?

That based upon the decomposition of the urea by either the alkaline hypobromite or hypochlorite of sodium, and measuring the volume of nitrogen evolved which is converted into weight, and as such corresponds in a certain ratio with the amount of urea decomposed.

What apparatus is used for this purpose, and how is the process conducted?

It consists of a flask containing a test tube with the urine to be examined; around this tube in the bottle is the NaClO or

NaBrO solution; connected with a glass tube through its stopper is a rubber tubing communicating with an inverted graduated burette floating in a cylinder of water. When the flask with the tube is inclined so that the urine will mingle with the NaBrO or NaClO solutions it is decomposed, the CO_2 being absorbed by the alkaline solution present while the N enters into the graduated burette displacing the water therein and is so read off in c.c.; these are converted into urea by multiplying with 0.0027, giving in grams the urea present in the urine decomposed.

How is the alkaline sodium hypobromite solution (Knop's solution) prepared?

100 grams NaOH are dissolved in 250 c.c. water, and to this 25 c.c. bromine are added.

In order to have accurate results what must be done?

The volume of nitrogen read off must be corrected for barometric pressure and temperature.

What formula is used for this purpose?

$$V^1 = \frac{v\ (b-w)}{760(1+0.00366\ t.)}$$

in which V^1= is the volume required; v= volume observed; b= barometric pressure; w= tension of aqueous vapor; t= observed temperature centigrade.

How does urea split up under the influence of the micrococcus ureæ?

It unites with water and forms ammonium carbonate.

$$CON_2H_4+2H_2O=(NH_4)_2CO_3.$$

In which morbid conditions is the amount of urea increased in the urine, and in which diminished?

During increased metabolism; in febrile and inflammatory affections it is increased, also in the different forms of diabetes; in acute yellow atrophy of the liver it may be entirely absent; in acute and chronic forms of Bright's disease it may be greatly diminished, causing low sp. gr. of the urine, and giving rise to uræmia from being retained in the circulation.

What is uric acid, and in what form is it derived from the urine?

It is a compound urea, $C_5H_4N_4O_3$, derived from the urine as a colored microscopical crystal of lozenge shape, either solitary or in clusters, the angles corresponding to the shortest diameter being rounded off.

Does uric acid occur free in the urine normally?

It does not occur free in normal urine but as salts, sodium, potassium, or ammonium urate; these are also found in the blood during gout and in fevers.

What is the clinical significance of the presence of free uric acid in the urine?

When present at micturition or shortly afterwards it may give rise to the formation of gravel.

How does uric acid form in the system?

As result of suboxidation of albuminoids, as an incomplete product in the formation of urea.

Of what are gout stones principally composed?

Sodium urate.

What are the properties of pure uric acid?

A white crystalline powder, odorless and tasteless, very little soluble in water, dissolving without decomposition in strong H_2SO_4, from which it is precipitated on addition of water; it is a dibasic acid forming with the alkaline bases both normal and acid salts.

What is the solubility of uric acid?

1 in 15,000–18,000; it is one of the most insoluble products of the body.

Why do urates form deposits in joints and cartilages?

Because they are poorly supplied with blood, which is a solvent for them.

What is the reaction of blood during gout?

It is less alkaline than normally.

Why are alkalies indicated in gout?

Because they increase the alkalinity of the blood so as to favor the elimination of the urates.

What diet and manner of living favor the formation of uric acid?

Red meats, heavy wine, rich food, and lack of exercise.

How is uric acid recognized chemically?

By the murexide test; to apply this dissolve the substance to be examined in a few drops of HNO_3, the solution is then reduced to dryness by gentle heating, leaving a yellowish residue; if this is moistened with NH_4OH a beautiful purple color, murexide, is developed if uric acid is present.

How is the amount of uric acid in urine determined?

200-300 c.c. urine are acidulated with 5-10 c.c. HCl and allowed to stand for 24 hours when the crystals formed are collected and washed on a tared filter; the dried filter being weighed, the increase of weight gives approximately the amount of uric acid.

Alkaloids.

What are alkaloids?

Nitrogenized vegetable compounds of basic character, forming salts with acids, by directly combining with them like ammonia.

How are they subdivided?

According to their physical condition into volatile and fixed alkaloids; those containing no oxygen are mostly liquid and volatile; others containing it are solid and non-volatile.

What are they chemically?

Tertiary (like the quinoline and pyridine bases) and secondary amines as far as they have been studied.

How do alkaloids behave towards solvents?

The free or basic alkaloids are generally insoluble or very little soluble in water, but soluble in ether, chloroform, amylic alcohol, benzin, carbon bisulphide, alcohol, and acids; as salts they are insoluble in these, but as a rule soluble in water.

Have all plants different alkaloids?

Different plants may have identical or analogous alkaloids, several natural orders having similar or analogous ones; one plant may have a number of them; thus nux vomica has three, ignatia has three, cinchona four, opium about twenty-one, etc.

Which are the general characteristics of alkaloids?

They are alkaline; form precipitates with tannic acid, forming insoluble tannates (for that reason tannin is used as an antidote for them); they are precipitated also by the fixed alkalies, also by phospho-tungstic acid, ammonium molybdate, potassium iodo-hydrargyrate, platinic chloride, picric acid, etc.

Why is it difficult to separate and determine poisonous alkaloids from cadavers?

Their separation is intricate and requires delicate manipulation; then they are present as a rule in minute quantities only; they are besides generally subject to decomposition during the decay of the body, and finally their differentiation from ptomaines offers great difficulty, as they often possess the same color reactions, and in some instances similar physiological effects.

What must be done to establish the identity of an alkaloid?

All the color tests must answer, besides the physiological action and taste.

On what depends the Staas-Otto method for extracting alkaloids?

Upon the fact that their acid salts are soluble in water, and can be rendered insoluble therein by alkalies as free bases; as such they are taken up by ether or chloroform, amylic alcohol, carbon bisulphide, etc., and from these recovered by evaporation of the solvents.

Which are the principal liquid alkaloids?

Nicotine $C_{16}H_{14}N_2$, coniine $C_8H_{15}N$, piperidine $C_5H_{11}N$, and sparteine $C_{15}H_{26}N_2$.

From what plant is nicotine obtained, and what are its properties?

It is obtained from tobacco; it is a colorless oily liquid of characteristic odor, is very poisonous, producing nausea, cold sweats, giddiness, cardiac depression, and difficulty of respiration. Treatment: wash out the stomach with a strong infusion of tea, charcoal, and stimulants.

Where is coniine obtained from, and what are its properties?

Coniine is obtained from hemlock (conium U. S); it is a colorless volatile liquid, of strong alkaline reaction, and penetrating odor. With HCl its vapors give rise to white clouds, as is also the case with NH_3; it is a powerful poison, causing paralysis of the muscles of the extremities, and when reaching the muscles of respiration death ensues from apnœa. Treatment, as in nicotine poisoning, with artificial respiration.

Which are the principal alkaloids from cinchona?

Quinine, quinidine, cinchonine, and cinchonidine.

What is quinine, and how recognized?

Quinine, $C_{20}H_{24}N_2O_2$, is in its basic state an amorphous white powder; it is freely soluble in acids, with which it forms crystalline salts, the sulphate being the one most in use; its acid solutions are fluorescent; treated with chlorine it turns green on the addition of NH_4OH, or red if potassium ferrocyanide is added.

Which are the principal opium alkaloids, and with what acid are they united in opium?

Morphine, codeine, narceine, narcotine, etc., united with meconic acid, as meconates in the natural state.

What is morphine, and what its properties?

An alkaloid of opium, $C_{17}H_{19}NO_3+Aq$, crystallizing in truncated prisms of alkaline reaction, combining with acids to form salts. The alkaloid is insoluble in ether and chloroform, very little soluble in water, more so in alcohol, and also in acetic ether; its salts are soluble in water and alcohol; insoluble in acetic ether.

Which are the symptoms produced by morphine poisoning?

Regular breathing, moist skin, livid lips, blue nose; further on irregularly rhythmical (Cheyne-Stokes) breathing, and coma. This is always an alarming symptom, but recovery is still possible, and the efforts to restore the patient should not be given up.

How does morphine or opium in toxic doses affect the pupils?

They are contracted; other alkaloids, such as eserine, aconitine, and strychnine, produce the same effect, but the general symptoms produced by them are different. It is to be remembered however that in apoplexy, involving the Pons varolii, the pupils are also contracted as in opium poisoning.

How soon may death result from morphine poisoning?

Symptoms may come on in from 15–30 minutes to an hour or three hours; dry pills may not produce effects for 6–12 hours. Death may take place in 45 minutes, but usually not before 8–10 hours.

What is the treatment of poisoning by morphine or opium?

Use the stomach pump; if early enough emetics, mustard, salt and water, and zinc sulphate; if no emesis is induced by these in a short time they must be abandoned. Wash out the stomach with strong tea, give animal charcoal, use faradism and artificial respiration, flagellation with wet towels, to keep up respiration by reflex irritation, best to the region of the trigeminus, keep the patient moving and awake, strong coffee, enemata with brandy; atropine is good as a respiratory stimulant.

By which tests can morphine be recognized?

HNO_3, orange-yellow color, shading off into yellow, Fe_2Cl_6, greenish-blue. Iodic acid is reduced by morphine, rendering color of solution brownish from free iodine, changing to bluish-black on addition of starch water.

What is tested for in looking for opium, and how?

Meconic acid; this gives a red color with ferric chloride, extinguished by stannous chloride, but not by mercuric chloride.

What is strychnine, and its properties?

An alkaloid extracted from nux vomica and ignatia, crystallizing in various modified forms of octahedra and four-sided prisms, which latter predominate. It is odorless, but of very bitter taste, and said to be recognizable when so dilute as 1 in 100,000, and can be readily recognized 1 in 50,000, and 1 in 10,000 it is distinctly bitter; it is soluble in 7000 parts of water, 1 in 1000 carbon disulphide, 1 in 340 ether, 1 in 100 alcohol, and 1 in 10 chloroform; it is markedly basic and stable.

Which is the principal salt of strychnine?

Strychnine sulphate $\overset{+}{St}_2H_2SO_4$; it does not char or color with H_2SO_4; dissolves in 10 parts of water and 60 alcohol; it is the principal ingredient in various vermin killers, and is largely used for destroying animals.

What symptoms does strychnine produce in poisonous doses?

Tetanic spasms; muscles of respiration are rigidly contracted, producing a sensation of suffocation; every muscle becomes contracted, lasting from ¼–1 minute; opisthotonos, broad grin, great pain, lockjaw, respiratory muscles and diaphraghm fixed, pupils contracted, dilating with relaxation of spasm; spasms come more and more rapidly until the victim dies of asphyxia and exhaustion.

What is the fatal dose of strychnine and its effect on infants?

Fatal dose 1–2 grains, but recovery has been reported from 40 grains. Infants may be poisoned by strychnine through the mother's milk, though the mother is not affected; this is attributable to the more irritable spinal cord of children.

How are cases of strychnine poisoning to be treated?

Give the usual antidotes for alkaloids, but if the patient resists or cannot take them on account of spasm, put him partially under the influence of chloroform and then give emetics and antidotes.

If emetics fail what is to be done?

Use the stomach-tube through perforated gag to prevent the patient from biting it during spasm, and inject through this strong infusions of oak bark or tea or solutions of tannin, and wash out the stomach thoroughly.

What are physiological antidotes for strychnine?

Chloroform, chloral, bromides; chloral by rectum 30–60 grains as required.

How may strychnine be recognized?

By the bitter taste, 1 in 10,000 or 5000 must give it distinctly; the bitter taste is even more delicate than the color test; if it is not bitter it is not strychnine, but though bitter it may be something else; H_2SO_4 produces no change with strychnine, but by the action of nascent oxygen it gives rise to a play of colors from blue to purple, violet, crimson, and orange-yellow.

How is nascent oxygen generated in the color-test for strychnine?

By H_2SO_4, to which is added a small fragment either of potassium bichromate or permanganate, or else manganese dioxide or lead peroxide.

What is known as the Marshall Hall's test?

The physiological test; it is done by injecting some of the suspected liquid subcutaneously into a small frog; if strychnine is present the animal will have tetanic spasms, etc.

What is brucine and its properties?

It is an alkaloid associated with strychnine in nux vomica and ignatia, frequently contained in the strychnine of the market; in action it only represents about $\frac{1}{10}$ the strength of strychnine; test for brucine is HNO_3 with which it turns bright red (brucine is also a test for HNO_3).

Which alkaloids derived from the solanaceæ are isomeric?

Atropine, from atropa belladonna, analogous to daturine from datura stramonium, hyoscyamine from hyoscyamus niger, and duboisine from duboisia myoporoides, all of which have the formula $C_{17}H_{23}NO_3$ and similar effects, dilating the pupils, and therefore termed mydriatics.

What is atropine?

An alkaloid of atropa belladonna, probably existing as a malate in the plant (daturine may be considered as analogous to it);

it is soluble in 400 parts of water, is of alkaline reaction, and freely soluble in alcohol, ether, and chloroform.

What is homotropine?

A synthetical product obtained from tropine and mandelic acid; it is employed as a substitute for atropine.

What are the symptoms of poisoning by atropine?

Giddiness, drowsiness, thirst, incoherent speech, and almost loss of articulation, dry mouth and throat, strong pulse, occasional vomiting, flushed face (erythema), dilated pupils, delirium, ischuria, coma, but death not usual; cause of poisoning most frequently from eating the berries of the deadly nightshade.

What antidotes should be employed in cases of poisoning by atropine?

Emetics, zinc sulphate, apomorphine hypodermically; stomach-pump if these fail; wash out the stomach with strong infusions of tea, oak-bark, or tannin solutions, and charcoal.

By which test can atropine be recognized?

With H_2SO_4 and a fragment of potassium bichromate it gives rise to an odor of orange blossoms or attar of roses and a green color.

What is the principal alkaloid of aconitum napellus?

Aconitine, $C_{33}H_{43}NO_{12}$, producing numbness and tingling of mouth, fauces, and extremities, cardiac failure, and death by syncope. The physiological effect on the tongue is the best test for its detection. Antidotes, same as for other alkaloids, together with cardiac stimulants.

What are ptomaines?

The basic products derived during the process of decay of cadaveric bodies.

What are leucomaines?

The basic products derived from organized bodies during life by the retrograde chemical process.

Are the ptomaines constant chemical bodies?

No, they vary according to the stage and the conditions supervening during decay, and are quite unstable.

How do the ptomaines compare with other amines?

Some of the well-known amines are produced during decay as ptomaines.

Are they all poisonous, and by what terms are the poisonous ptomaines known from the non-poisonous?

They are by no means all poisonous; but for those of a poisonous character the affix of "toxine" has been proposed, such as typhotoxine, etc.

Name some of the known ptomaines.

Neurine, neuridine, muscarine, cadaverine, mydæline, sepsine, saprine, putrescine, collidine and hydrocollidine, mydatoxine, mydine and methylguanidine, typhotoxine, and tyrotoxicon, etc.

What is tyrotoxicon?

The poisonous ptomaine of putrid cheese and putrid decomposition of milk; it is claimed to be a diazobenzol, $C_6H_5N_2C_4H_7O_2$.

Name some of the leucomaines.

Guanin, xanthin, hypoxanthin, creatin, and creatinin.

Proteids.

What are proteids or protein bodies?

Albuminoids or albuminous bodies constituting the principal component of the animal organism, and also present in plants and seeds.

How are they chemically constituted?

Their molecules have a very complex composition, but always contain nitrogen.

In which way can they be studied?

By their products of decomposition, resulting both from chemical and putrefactive changes.

What are the two principal states in which they occur?

In the soluble and insoluble state; the latter being derived from the former by heat and various chemical bodies; the insoluble albuminoids cannot be directly reconverted into the soluble.

Of what elements are the albuminoids principally composed?

Carbon, oxygen, nitrogen, hydrogen, and sulphur.

Which are the general tests for the recognition of albuminoids?

With the alkaline cupric (Fehling's) solution they give a violet coloration; with strong nitric acid they give a yellow coloration, changing with ammonia water to a brownish-red on cooling; this is known as the xanthoproteic reaction; with Millon's reagent they give a rose or red coloration.

What are the two principal albumins?

Eggalbumen as occurring in white of eggs, and serumalbumin as present in the serum of the blood.

How can these two be distinguished?

Eggalbumen coagulates when shaken with ether; serumalbumin does not.

What is serumalbumin?

In its dry state it is yellowish and transparent; it exists in solution in the serum of the blood and other fluids of the body, and pathologically also in the urine at times.

Are other albuminoids besides serumalbumin secreted from the urine at times?

Serumalbumin is the principal one, but globulin, albuminose, peptone, hæmialbuminose, and mucine may also be present in urine under certain conditions.

What changes may serumalbumin undergo in the urine?

It may be changed by alkalies into alkali-albumin and by stronger acids into acid-albumin, both of which are not coagulable on boiling; if the urine is alkaline from ammonia or other alkalies it has to be neutralized and rendered slightly acid.

Which are the two most reliable tests for detecting albumin in urine?

Boiling and the contact method with HNO_3.

How is the boiling test performed?

If urine is not acid render it so with a drop or two of acetic acid (if too much acid is added, uncoagulable acid-albumin is formed). Heat the upper portion of the urine in the test-tube, so as to have two strata for comparison, and if at or near the boiling-point a coagulum or turbidity results, albumin is present.

What is the contact method (Heller's), and how applied?

It is a ready and accurate method for bedside testing, and very reliable. Put a small quantity of urine into a test-tube, and, after inclining the latter, carefully pour in a little nitric acid so that there will be two distinct layers; if albumin is present there will be a cloudy zone between the acid and the urine.

How may this reaction be simulated?

If the patient has been taking copaiba, which, however, will become apparent by its odor.

How may the quantity of albumin in urine be approximately expressed for clinical purposes?

By the proportion of the bulk of precipitated albumin after standing for 24 hours to the total volume of the fluid employed, as, for instance, $\frac{1}{4}$ or $\frac{1}{10}$ albuminous layer, etc.

How much albumin is usually in the urine of albuminuria, and what is the greatest amount that can be in it?

It is rarely present in more than $\frac{1}{10}$–$\frac{1}{2}$ per cent., but may rise to 1 and even 4 per cent.

How is the quantity of albumin in the urine approximately determined with Esbach's albuminometer?

By precipitating it with acidulated solution of picric acid in a graduated tube which indicates the relation of the volume of its precipitate to dry albumin, as follows: fill the tube to U with the urine and add picric acid solution to R, let stand for 24 hours, after which read off according to the graduation the amount of dry albumin contained in a liter of urine.

What may give rise to the presence of albumin in urine?

Renal disease, characterized by the presence of casts, also blood or pus from some part of the uropoetic apparatus.

Are traces of albumin in urine always indicative of renal lesions?
No, unless casts are also found.

How are blood and pus best detected in the urine?
By the characteristic appearance of their corpuscles under the microscope.

How do albuminoids split up in peptic digestion?
They are considered to contain a hemi- and anti-group, the former splitting up into antialbumose and antipeptone, the latter into hemialbumose and hemipeptone.

What is peptone, and its destination?
It is a soluble albuminoid, noncoagulable by heat or nitric acid, resulting in consequence of peptic digestion; it is intended to be reconverted by the function of the liver into serumalbumin, if this is not accomplished it may circulate as such and be excreted by the kidneys without causing serious trouble to health. If it is excreted in large quantities it causes peptonuria, detected by overlaying Fehling's solution with urine, when a roseate color will appear on the line of contact.

What is mucin?
A substance resembling albuminoids, but containing no sulphur; it is a product of the mucous membranes, precipitated by dilute HNO_3 but not by strong. It is not coagulated by heat, soluble in alkalies, but precipitated by acids; from urine containing it in solution it is precipitated best by acetic acid.

Which are the principal globulins, and what do they form?
The metaglobulin or fibrinogen and the paraglobulin or fibrinoplastin; they form in the presence of fibrin ferment the coagulated albuminoid fibrin.

What is fibrin?
A white elastic substance, which separates from blood on standing but does not pre-exist as such in it.

What is alkali albumin?
A modification of albumin produced by the action of alkalies on solutions of albumin; it is present in the blood, chyle, mus-

cles, etc.; it is uncoagulable by boiling and contains no sulphur.

What is acid albumin?

Syntonin, albumose, or parapeptone; it is obtained when solutions of albumin are treated with acids, and is not coagulable by boiling.

What is casein?

An albuminoid found in milk resembling alkali albumin but containing sulphur; it is not coagulated by boiling but precipitated from its solutions by rennet and acids.

What is gelatin, and how obtained?

Gelatin is the collagen of white connective tissue; it is amorphous, translucent, yellowish, almost colorless and tasteless, swells up in cold and dissolves in hot water, cooling into a jelly. It is insoluble in alcohol and ether but soluble in glycerin; it is precipitated from its solutions by tannin but not by alum. It is obtained from bones, tendons, etc., the collagen of which is by boiling with water converted into gelatin.

Coloring Bodies.

How may the soluble pigments of the body be regarded as forming?

Originally from the blood coloring matter, hæmoglobin, changing to hæmatin and hæmotoidin, this to the biliary pigments bilirubin and biliverdin, while the hydrobilirubin of the fæces may be considered identical with the urobilin of the urine.

What is hæmoglobin?

Hæmato-globulin, hæmatocrystallin, cruorin, or erythrocruorin, is a crystalline substance of complex composition containing all the elements of albumin plus iron.

Where is it found?

In the red corpuscles of the blood.

Describe its properties.

It is a crystalline solid, not diffusible, of red color, capable of existing in two modifications, as oxyhæmoglobin and reduced hæmoglobin or hæmoglobin; the former being scarlet-red and the latter purplish. It is soluble in water and alkaline solutions, and insoluble in alcohol and ether.

How can oxyhæmoglobin and reduced hæmoglobin be distinguished?

By the spectroscope; the absorption spectrum of the former exhibiting two bands, in D and E, while the latter shows one band between D and E.

When and how do the changes in hæmoglobin take place?

The oxyhæmoglobin in the tissues gives off some of its oxygen, and forms hæmoglobin, which in the lungs takes up oxygen, and again forms oxyhæmoglobin.

What is the function of hæmoglobin?

To carry oxygen to the tissues.

How is oxyhæmoglobin changed in watery solution?

Into methæmoglobin, another modification, recognized by its absorption spectrum, which exhibits a band between C and D and two more, a larger and a smaller, between D and E.

When hæmoglobin is treated with dilute acids or alkalies what results?

It is decomposed into globin or globulin and a ferruginous pigment hæmatin. This, according to its acid or alkaline state, gives two different spectra, of which the acid hæmatin exhibits two bands, one between C and D, and a larger one between D and E; the alkaline hæmatin exhibits one band only, between C and D and closer to the latter. Reduced hæmoglobin treated as the former produces reduced hæmatin, recognized by two bands, one between D and E, and another to the right of E.

What effect has carbon monoxide on hæmoglobin?

It produces carbonic oxide hæmoglobin, recognized by exhibiting two bands in the spectrum similarly situated as those of oxyhæmoglobin, but the right is narrower than that of the latter. Carbonic oxide hæmoglobin besides is a stable compound, and cannot be reduced as the oxy-modification.

How can hæmoglobin be recognized?

By the ozone test, which is applied by adding to the suspected liquid a few drops of fresh tincture of guaiacum, giving it a milky-white color; upon adding to this, and shaking it with a little old spirits of turpentine or ethereal solution of hydrogen peroxide, an indigo-blue color is developed if hæmoglobin is present; this may be equally as well applied to dry-blood stains.

Which is the best test for hæmoglobin?

The hæmin test. This consists of taking some of the suspected liquid, coagulating it by boiling with a drop of acetic acid; the coagulum after drying is mixed in a minute proportion with a trifle of sodium chloride on a microscopic slide, a drop or two of glacial acid is then added, and it is brought to the boiling-point, when upon cooling there will be seen under the microscope characteristic purplish or brownish-red rhombic prisms or plates of hæmin or hæmatin hydrochloride (Teichmann's crystals).

Under what two conditions may hæmoglobin appear in the urine?

In hæmaturia and hæmoglobinuria.

What is hæmaturia?

The pathological condition characterized by the presence of blood corpuscles in the urine.

What is hæmoglobinuria?

The pathological condition characterized by the presence of hæmoglobin in solution in the urine without having corpuscular form.

Hæmatoidin, what is it?

Yellow crystals occurring in old extravasations; its formula is $C_{30}H_{34}N_4O_6$, which makes it homologous with bilirubin, though they differ spectroscopically.

Which are the two principal biliary pigments?

Bilirubin and biliverdin.

How is bilirubin supposed to be derived from hæmatin?

By combining with water as follows:—

$$\underset{\text{Hæmatin.}}{3(C_{32}H_{36}N_4FeO_6)} + 3H_2O = \underset{\text{Bilirubin.}}{6(C_{16}H_{18}N_2O_3)} + 3FeO.$$

What is bilirubin?

The principal coloring matter of the bile.

What is biliverdin?

A modification, or rather an oxidized product of bilirubin, forming spontaneously when alkaline solutions of bilirubin are exposed.

How are the biliary pigments recognized?

By Gmelin's test.

Describe Gmelin's test.

Add nitric acid to the suspected liquid, and if biliary pigments are present a green precipitate will form, which, on addition of more acid, gives rise to a play of colors from green, blue, violet, and red to yellow; this is best shown if a few drops of bile or liquor containing it and nitric acid are allowed to flow together on a porcelain plate when the colors will appear at the line of contact.

Which is the principal urinary pigment?

Urobilin, $C_{32}H_{44}N_4O_7$, identical in composition with hydrobilirubin, the modified biliary pigment in the fæces.

What is the indican of the urine?

A yellowish pigment, sometimes called uroxanthin, contained in some urines; with HCl it turns reddish-blue or blue from the formation of indigo; chemically it is an indoxyl-potassium sulphate, and originates from the indol of the fæces.

Which pigment gives urine the brownish-black color of certain pathological conditions?

Uromelanin, a black coloring body corresponding to the choroidal pigment and that of melanotic tumors.

APPENDIX.

Table of Elements.

	Symbols.	Atomic valence.	Atomic weight.
Aluminium	Al	iii	27
Antimony (Stibium)	Sb	iii, v	119.6
Arsenic	As	iii, v	74.9
Barium	Ba	ii, iv	136.8
Beryllium (Glucinum)	Be	ii	9.1
Bismuth	Bi	iii, v	207
Boron	B	iii	10.9
Bromine	Br	i, iii, v, vii	79.8
Cadmium	Cd	ii	111.9
Cæsium	Cs	i	132.7
Calcium	Ca	ii	39.9
Carbon	C	ii, iv	12
Cerium	Ce	iii, v	141
Chlorine	Cl	i, iii, v, vii	35.4
Chromium	Cr	ii, iv	52.4
Cobalt	Co	ii, iv, vi	58.6
Copper (Cuprum)	Cu	ii	63.2
Didymium	D	iii	144.6
Erbium	Eb	iii	165.9
Fluorine	F	i	19
Gallium	Ga	iii	69.8
Gold (Aurum)	Au	i, iii	196.2
Hydrogen	H	i	1
Indium	In	iii	113.4
Iodine	I	i, iii, v, vii	126.6
Iridium	Ir	ii, iv	192.5
Iron (Ferrum)	Fe	ii, iv, vi	55.9
Lanthanum	La	iii	138.2
Lead (Plumbum)	Pb	ii, iv	206.4
Lithium	Li	i	7
Magnesium	Mg	ii	23.9
Manganesium	Mn	ii, iv, vi	54.8
Mercury (Hydrargyrum)	Hg	ii	199.8
Molybdenum	Mo	ii, iv, vi	95.8
Nickel	Ni	ii, iv	58.6
Niobium	Nb	iii, v	94
Nitrogen	N	i, iii, v	14
Osmium	Os	ii, iv, vi, viii	195
Oxygen	O	ii	16
Palladium	Pd	ii, iv	106.2
Phosphorus	P	iii, v	31
Platinum	Pt	ii, iv	194.3
Potassium (Kalium)	K	i	39
Rhodium	Rh	ii, iv	104.1
Rubidium	Rb	i	85.3
Ruthenium	Ru	ii, iv, vi, viii	104.2
Scandium	Sc	iii	44
Selenium	Se	ii, iv, vi	78.9
Silicium	Si	iv	28
Silver (Argentum)	Ag	i	107.7
Sodium (Natrium)	Na	i	23
Strontium	Sr	ii, iv	87.3
Sulphur	S	ii, iv, vi	32
Tantalum	Ta	v	182
Tellurium	Te	ii, iv, vi	126
Thallium	Tl	i, iii	203.6
Thorium	Th	iv	232
Tin (Stannum)	Sn	ii, iv	117.5
Titanium	Ti	iv	48
Tungsten or Wolfram	W	ii, iv, vi	183.6
Uranium	U	iv, vi	239
Vanadium	V	iii, v	51.2
Ytterbium	Yb	iii	173
Yttrium	Y	iii	89
Zinc	Zn	ii	64.9
Zirconium	Zr	iv	90

Weights and Measures.

METRIC AND ENGLISH WEIGHTS.

1 milligram	= 0.001 gram.	= 0.015 gr. Troy.	1 grain Troy,	= 0.0648 gram.
1 centigram	= 0.01 "	= 0.154 " "	1 drachm Troy,	= 3.888 grams.
1 decigram	= 0.1 "	= 1.543 " "	1 ounce "	= 31.103 "
1 gram	=	= 15.434 grs. "	1 " Br. P.	= 28.35 "
1 decagram	= 10 grams	= 154.34 " "	1 " Avoird.	= 28.35 "
1 hectogram	= 100 "	= 3.53 ozs. "	1 pound Troy, 12 oz.	= 373.242 "
1 kilogram	= 1000 "	= 35.27 " "	1 " Avoird.	= 453.6 "

METRIC AND ENGLISH MEASURES.

1 millimetre	= 0.001 metre	= 0.03937 inch.	1 inch	= 0.0254 metre.
1 centimetre	= 0.01 "	= 0.3937 "	1 foot	= 0.3048 "
1 decimetre	= 0.1 "	= 3.937 inches.	1 yard	= 0.9144 "
1 metre	=	= 39.3704 "	1 rod	= 5.0292 metres.
1 decametre	= 10 metres	= 32 ft. 9.7 "	1 furlong	= 201.1662 "
1 hectometre	= 100 "	= 328 " 1 inch.	1 mile	= 1609.3297 "
1 kilometre	= 1000 "	= 3280 " 10.4 inches.		

METRIC AND APOTHECARIES' FLUID MEASURES.

1 millilitre, cubic centimetre or C. C.	= 0.001 litre	= 16.23 minims.	1 minim	= 0.061 c. c.
1 centilitre	= 0.01 "	= 2.71 fluiddrachms.	1 fluiddrachm	= 3.7 "
1 decilitre	= 0.1 "	= 3.38 fluidounces.	1 fluidounce	= 29.6 "
1 litre	=	= 33.81 fluidounces.	1 pint	= 0.47 litre.
1 decalitre	= 10 litres	= 2.6417 galls.	1 quart	= 0.946 "
1 hectolitre	= 100 "	= 26.417 "	1 gallon	= 3.785 litres.
1 kilolitre	= 1000 "	= 264.17 "		

RULES FOR CONVERTING APOTHECARIES' INTO METRIC WEIGHTS AND MEASURES APPROXIMATELY.

(According to Oldberg.)

1. To express quantities by weight of the Apothecaries' system in metric terms, or to write medical prescriptions in metric weights.

RULE A. Reduce each quantity to grains; then divide the number by 10 (or move the decimal point one place to the left), and from the quotient subtract one-third. The remainder is in each case the number of grams representing (nearly) the same quantity. Or,

Rule B. Reduce each quantity to drachms, and multiply the number by 4. The product is in each case the number of grams representing (nearly) the same quantity. Or,

Rule C. Reduce each quantity to ounces, and multiply the number by 32. The product is in each case the number of grams representing (nearly) the same quantity.

2. To express quantities by measure of the Apothecaries' system in metric terms, or to write medical prescriptions in metric cubic measures.

Rule D. Reduce each quantity to minims; then divide the number by 10 (or move the decimal point one place to the left), and from the quotient subtract one-third. The remainder is in each case the number of cubic centimetres representing (nearly) the same quantity. Or,

Rule E. Reduce each quantity to fluiddrachms, and multiply the number by 4. The product is in each case the number of cubic centimetres representing (nearly) the same quantity. Or,

Rule F. Reduce each quantity to fluidounces, and multiply the number by 32. The product is in each case the number of cubic centimetres representing (nearly) the same quantity.

Table of Equivalents of Centigrade and Fahrenheit Thermometric Scales.

Cent.	Fahr.	Cent.	Fahr.	Cent.	Fahr.	Cent.	Fahr.	Cent.	Fahr.	Cent.	Fahr.
°	°	°	°	°	°	°	°	°	°	°	°
—40	—40.0	—15	+5.0	+9	+48.2	+33	+91.4	+57	+134.6	+81	+177.8
39	38.2	14	6.8	10	50.0	34	93.2	58	136.4	82	179.6
38	36.4	13	8.6	11	51.8	35	95.0	59	138.2	83	181.4
37	34.6	12	10.4	12	53.6	36	96.8	60	140.0	84	183.2
36	32.8	11	12.2	13	55.4	37	98.6	61	141.8	85	185.0
35	31.0	10	14.0	14	57.2	38	100.4	62	143.6	86	186.8
34	29.2	9	15.8	15	59.0	39	102.2	63	145.4	87	188.6
33	27.4	8	17.6	16	60.8	40	104.0	64	147.2	88	190.4
32	25.6	7	19.4	17	62.6	41	105.8	65	149.0	89	192.2
31	23.8	6	21.2	18	64.4	42	107.6	66	150.8	90	194.0
30	22.0	5	23.0	19	66.2	43	109.4	67	152.6	91	195.8
29	20.2	4	24.8	20	68.0	44	111.2	68	154.4	92	197.6
28	18.4	3	26.6	21	69.8	45	113.0	69	156.2	93	199.4
27	16.6	2	28.4	22	71.6	46	114.8	70	158.0	94	201.2
26	14.8	1	30.2	23	73.4	47	116.6	71	159.8	95	203.0
25	13.0	0	32.0	24	75.2	48	118.4	72	161.6	96	204.8
24	11.2	+1	33.8	25	77.0	49	120.2	73	163.4	97	206.6
23	9.4	2	35.6	26	78.8	50	122.0	74	165.2	98	208.4
22	7.6	3	37.4	27	80.6	51	123.8	75	167.0	99	210.2
21	5.8	4	39.2	28	82.4	52	125.6	76	168.8	100	212.0
20	4.0	5	41.0	29	84.2	53	127.4	77	170.6	101	213.8
19	2.2	6	42.8	30	86.0	54	129.2	78	172.4	102	215.6
18	0.4	7	44.6	31	87.8	55	131.0	79	174.2	103	217.4
17	+1.4	8	46.4	32	89.6	56	132.8	80	176.0	104	219.2
16	3.2										

RULES FOR CONVERTING CENTIGRADE INTO FAHRENHEIT.

(D to stand for the degree to be converted.)

If above the freezing point of water, 32° F. (0° C.), $\frac{D}{5} \times 9 + 32.$

If below freezing, but above 0° F. (—17.77° C.), $32 - \left(\frac{D}{5} \times 9\right)$

If below 0° F. (—17.77° C.) $-\left(\frac{D}{5} \times 9\right) - 32.$

RULES FOR CONVERTING FAHRENHEIT INTO CENTIGRADE.

If above the freezing point of water, 32° F. (0° C.), $\frac{(D-32)}{9} \times 5.$

If below freezing, but above 0° F. (—17.77° C.) $-\frac{(32-D)}{9} \times 5.$

If below 0° F. (—17.77° C.) $-\frac{(D+32)}{9} \times 5.$

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